CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 21/22 HAER No. FL-8-AO
4126 Lighthouse Road
Cape Canaveral
Brevard County
Florida

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
Southeast Regional Office
National Park Service
U.S. Department of the Interior
100 Alabama Street, S.W.
Atlanta, GA 30303

HISTORIC AMERICAN ENGINEERING RECORD

CAPE CANAVERAL AIR FORCE STATION, LAUNCH COMPLEX 21/22

HAER No. FL-8-AO

Location:	Cape Canaveral Air Force Station Launch Complex 21/22 4126 Lighthouse Road Cape Canaveral Brevard County Florida USGS Cape Canaveral Quadrangle, Universal Transverse Mercator Coordinates: 17/3148750.65/544971.20
Date of construction:	1957
Engineer:	U.S. Army Corps of Engineers
Present owner:	U.S. Air Force
Present Use:	Deactivated
Significance:	Launch Complex 21/22 is significantly associated with early missile development testing for the U.S. military, specifically the U.S. Air Force. Information gathered from these tests also assisted the U.S. early missile and space program. Launch Complex 21/22 served as a research and development missile launching site from 1957 through 1963. During this time, it hosted launches of the Bull Goose/Goose, and Mace missiles.
Report prepared by:	Dr. Susan Enscore, Ms. Julie Webster, Ms. Angela Fike, and Mr. Martin Stupich U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory 2902 Newmark Drive Champaign, IL 61822
Date	July 2008

HISTORICAL OVERVIEW OF CAPE CANAVERAL AIR FORCE STATION

Cape Canaveral Air Force Station[1]

Cape Canaveral Air Force Station (CCAFS) is located in Brevard County on the east coast of central Florida, approximately 155 miles south of Jacksonville and 210 miles north of Miami (see Figure 1). It occupies 15,804 acres and is bounded by the Atlantic Ocean to the east and the Banana River to the west. A barge and ship channel called Port Canaveral is located to the south while the John F. Kennedy Space Center is located to the west and north.[2] Cape Canaveral Air Force Station is part of the Eastern Range including administrative headquarters at nearby Patrick Air Force Base, launch sites at Cape Canaveral and Kennedy Space Center, and downrange tracking facilities that extend 10,000 miles down the Atlantic into the Indian Ocean.

Cape Canaveral and the Cold War

As the launching site for a majority of the U.S. missile and space programs, both military and civilian, CCAFS played a critical role during the Cold War. This era in history, spanning roughly from 1946 to 1989, pitted the ideologies, economies, technologies, and military power of the United States and the Soviet Union against each other.[3] This struggle originated in Europe but eventually spread around the globe. The defining feature of the Cold War was the massive arms race that developed between the Soviet Union and the United States. This arms race relied heavily on constantly advancing technology. The Soviet Union and the United States both developed massive missile and space programs after World War II. Although military and political goals fueled the early missile and space efforts of the United States, one important offshoot of these efforts was the emergence of a separate civilian space program. The civilian space program, which included both manned and unmanned missions, grew alongside and benefited from the military missile and space programs. The military programs, in turn, also benefited from the successes of the civilian space program.

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[1] This historical overview is utilized in all ERDC-CERL HABS/HAER reports for Cape Canaveral Air Force Station for reasons of continuity. It was authored in its original form by Patrick Nowlan and Chad Randl in 1993. It has since been edited and expanded by Susan Enscore.

[2] David Barton and Richard S. Levy, An Architectural and Engineering Survey and Evaluation of Facilities at Cape Canaveral Air Force Station, Brevard County, Florida, (Resource Analyst, Inc., 16 March 1984), 1.

[3] These dates correspond to Winston Churchill's "Iron Curtain" speech delivered at Westminster College in Missouri and the destruction of the Berlin Wall, an event generally accepted as signifying the end of the Cold War.

Origins of the U.S. Missile Program

America's early efforts in rocketry revolved around the work of Robert H. Goddard. Goddard conducted experiments with rockets in the 1920s and 1930s, carrying out the first recorded launching of a liquid-propelled rocket on March 16, 1926.[4] Some of Goddard's more impressive achievements include adapting the gyroscope to guide rockets, installing movable deflector vanes in a rocket exhaust nozzle scope to guide rockets, patenting a design for a multistage rocket, developing fuel pumps for liquid fuel motors, experimenting with self-cooling and variable thrust motors, and developing automatic parachute deployment for recovering instrumented rockets.[5]

Around the time Goddard was conducting his experiments, the Germans were also engaging in rocket research. In 1937 and 1938, they established huge research and test facilities at Peenemünde on the Baltic where they developed the V-1 "buzz bomb" and the more advanced V-2 ballistic rocket. Although the U.S. military experimented with some crudely developed guided missiles during World War II, there was not much interest in rocketry among U.S. military leaders until the Germans began firing their V-1 and V-2 rockets at Allied cities in the summer of 1944. Allied anti-aircraft batteries quickly learned to shoot down the slow-flying V-1. There was no defense, however, against the 3,500 mile-per-hour V-2. The German V weapons made it clear that missiles would revolutionize the future of warfare. Recognizing this, the different branches of the U.S. armed services scrambled to create their own missile programs, each hoping to gain future operational and deployment responsibility.

Immediately after World War II, the Army brought several hundred German engineers and scientists, including Dr. Wernher von Braun, to the United States during Operation "Paperclip." The Army organized a team of rocket specialists from Peenemünde, including Dr. von Braun, at Fort Bliss, Texas to conduct studies concerning the development of long-range surface-to-surface guided missiles. In an effort to refine the German V-2, these scientists began helping the Army test launch captured V-2 rockets at the adjacent White Sands Proving Grounds in May 1946. In 1950, the Army moved the team to the Redstone Arsenal in Huntsville, Alabama, where they began to develop the Redstone missile.

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[4] Young, Warren R., ed., To The Moon, (New York, NY: Time-Life Records, 1969), 21.

[5] Ibid., 18.

The Navy and Air Force also began their own missile programs in the 1940s. For a brief time, however, it appeared that a single national guided missile program might be established to eliminate duplication of effort among the services. The Army and Navy both favored such a development. But the Air Force (at that time still known as the Army Air Forces or AAF)[6] strongly opposed such a plan. AAF officials feared that a single program would jeopardize their chance of gaining sole responsibility for development and deployment of long-range guided missiles.[7] Consequently, fierce inter-service rivalries developed as each service sought to define its role and mission in the development and control of guided missiles.

In 1949, Secretary of Defense Louis A. Johnson initiated a review of the nation's missile programs in an attempt to clarify the roles of each service branch and to reduce the waste resulting from the duplication of effort. The Air Force emerged from this review with "formal and exclusive" responsibility for developing long-range strategic missiles and short-range tactical missiles. Even after the review, however, both the Army and Navy continued to conduct missile "studies" that eventually progressed to the development stage.[8]

Aside from the inter-service bickering, a major obstacle to long-range missile development for the United States in the 1940s was lack of a range large enough to test new missiles. The nation's largest missile range in 1946 was the White Sands Proving Grounds in New Mexico and it was only 150 miles long.[9] In order for the United States to develop long-range missiles, a new missile proving ground would have to be established.

Committee on Long Range Proving Grounds

In October of 1946, the Joint Research and Development Board of the War Department (later the Department of Defense/DoD) created the Committee on Long Range Proving Grounds. Charged by the War Department with selecting a site that would be suitable for a

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[6] The National Security Act of 1947 divided the military services into the three separate departments of the Army, the Navy, and the Air Force.

[7] Jacob Neufeld, The Development of Ballistic Missiles in the United States Air Force, 1945-1960, (Washington, DC: Office of Air Force History, United States Air Force, 1990), 50-52.

[8] Ibid., 55-56.

[9] "Cape History: Establishment of the Eastern Test Range," Spaceport News, 14 October 1977.

long-range proving ground, the committee considered sites in California, Georgia, Texas, and Florida.[10]

The committee's first choice was the El Centro Marine Corps base in the Gulf of California area. The U.S. government immediately initiated negotiations with the Mexican government to secure sovereignty rights for tracking stations. When these negotiations failed, the committee then recommended the Cape Canaveral area in Florida. Cape Canaveral had several factors working in its favor, not the least of which was an over-water range that would allow long-range missile flights over an area relatively free from major shipping lanes and inhabited land masses. In addition, the numerous islands extending out into the Atlantic Ocean offered suitable locations for permanent stations to track missile flights and record performance information. The relative isolation of the Cape area was ideal for safety and security reasons and the weather conditions of the area would allow for year round operation.[11] Also, the Banana River Naval Air Station, located only about twenty miles from the Cape, would make an ideal support base. Aside from these advantages, locating the missile proving ground at Cape Canaveral also had economic advantages. The U.S. government already owned portions of the Cape and the undeveloped land on the Cape was considerably less expensive than land at other locations.[12]

Initial Developments

The DoD accepted the committee's recommendations and officially chose the Cape Canaveral area as the site for the envisioned missile test center. In May of 1949, President Truman signed Public Law 60 authorizing the establishment of the joint long-range proving ground to be used by the Army, Navy and Air Force for the development and testing of missiles and other weapons.[13] The Department of Defense assigned responsibility for developing the range to the newly created Department of the Air Force. Brig. General William L. Richardson was named to direct the project.[14] During the next few years, the U.S. Government acquired land in the Cape area and began negotiations with the British government to acquire islands in the Bahamas and West Indies for use as

[10] Barton and Levy, Architectural and Engineering Survey and Evaluation, 3.

[11] From Sand to Moondust: A Narrative of Cape Kennedy, Then and Now, (U.S. Air Force and Pan American World Airways, Inc., 1974), 9.

[12] Barton and Levy, Architectural and Engineering Survey and Evaluation, 3.

[13] "Cape History: Establishment of the Eastern Test Range."

[14] "Master Plan of the Cape Canaveral Missile Test Annex," (Pan American World Airways, Inc., 1971), 1.

tracking sites. The negotiations concluded with the signing of the Bahamas Agreement on July 21, 1950, permitting construction of downrange stations on such islands as Grand Bahama, Grand Turk, Antigua and Ascension.[15] Future downrange stations were added as far away as Pretoria in South Africa.

On June 10, 1949, the Banana River Naval Air Station was reactivated and an advance headquarters was set up there on October 1, 1949.[16] Brigadier General Richardson assumed command the following April. The name of the Banana River Naval Air Station was changed on August 1, 1950 to Patrick Air Force Base in honor of Major General Mason M. Patrick, the Army Air Corps' first Chief. During that same year, construction began on the first missile launching pad (Pad 3) and the first support facilities at Cape Canaveral. In June, Cape Canaveral was officially declared operational and became Operating Sub-Division No. 1 or Station 1 of the Joint Long Range Proving Ground.[17]

Name Changes

Over the years the installation at the Cape, and the entire range, underwent numerous name changes. Initially known as the Joint Long Range Proving Ground, the range became known as the Long Range Proving Ground in 1950. By 1952, it was known unofficially as the Florida Missile Test Range and on May 1, 1958, it was officially designated the Atlantic Missile Range. The name was changed once again in May of 1964 to the Air Force Eastern Test Range (AFETR). The latest redesignation occurred in the fall of 1990 when the range became simply the Eastern Range. Operating Station 1 or Sub-division No. 1 was commonly known as Cape Canaveral from 1950 to 1963.[18] In November of 1963, the Cape area was officially named Cape Kennedy in honor of President Kennedy, but early in 1974 the name was changed back to Cape Canaveral.[19] In April 1994, the name was changed yet again to Cape Canaveral Air Station and to the current Cape Canaveral Air Force Station in 2000.

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[15] "Cape History: Establishment of the Eastern Test Range."

[16] The Navy had transferred the installation to the Air Force several years earlier.

[17] Barton and Levy, Architectural and Engineering Survey and Evaluation, 4.

[18] Ibid., 9. Between October 5, 1951 and December 15, 1964, the Cape was designated as Cape Canaveral Auxiliary Air Force Base. Between December 15, 1955 and January 22, 1964, the Cape carried the designation Cape Canaveral Missile Test Annex.

[19] Ibid.

Land Acquisition in the Cape Area

The U.S. government contracted with Sverdrup and Parcel to conduct a land survey of the Cape Canaveral area in January of 1948. The government began acquiring land on the Cape in 1950. Of the original 12,000 acres acquired, 2,328 acres were purchased by the end of 1950. The U.S. government acquired the south half of the launching area as a result of condemnation petitions from April to June of 1950 and acquired the north half of the launching area in June of 1950. In 1951, the value of government-acquired land and facilities at the Cape totaled about $7,500,000.00.[20] In 1956 and 1957, the government acquired an additional 682 acres in the south Cape area and from 1956 to 1959, 1,924 acres were acquired in the north Cape area. The total acreage at the Cape by 1959 was approximately 14,600 acres.[21] Later acquisitions brought the total up to 15,804 acres.[22]

CONSTRUCTION HISTORY OF CAPE CANAVERAL

Early Construction at Cape Canaveral

Extensive construction was necessary to prepare Cape Canaveral for its role as a missile research and development test center. The first facilities built at Cape Canaveral were technologically primitive by today's standards. Many of the early structural designs became obsolete as missile technology advanced. Although facilities within launch complexes were often adapted and re-used for other functions, launch complexes designed for one type of missile or missile series were rarely used for subsequent missile programs because complexes that were useful for one missile or missile series were not configured to handle the later, often larger and more sophisticated missiles. It was generally more cost effective to build a new launch complex than to adapt an existing launch complex. Some obsolete complexes were salvaged for reusable metal, sold to scrap metal dealers, demolished, or in a few cases used in the testing of anti-tank weapons.[23]

The Department of Defense designated the Corps of Engineers as the prime construction agency at Cape Canaveral and nearby Patrick Air Force Base. The Jacksonville District Corps of Engineers established a small area office at Patrick Air Force Base in May of 1950 and awarded a contract for the construction

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[20] "Master Plan of the Cape Canaveral Missile Test Annex," 2.

[21] Barton and Levy, Architectural and Engineering Survey and Evaluation, 4.

[22] Ibid., 1.

[23] Ibid., 55.

of the first launch pad at the Cape. The launch pad (Pad 3) was completed by June of 1950.[24] During the following month, the Army used the pad to launch the first missile from Cape Canaveral.

The Canaveral area office of the Corps under the Jacksonville District supervised and inspected $1.7 million in construction work and $700,000 in road contracts in the six months after the Bumper launch.[25] During the next three years, contractors constructed facilities for testing of cruise type missile weapons such as the Matador, the Snark and the Bomarc. The Air Force test-launched these missiles from Complexes 1 through 4. These complexes were located in an area northeast of the lighthouse at the point of the Cape. Other structures built in the area around this time included a communications building, a water plant, a fire station and several camera tower roads. Tracking stations, an administrative area, and a bivouac area were built just northwest of this point. A skid strip was constructed in the center of the Cape and more camera tower roads, a guidance station, sky screen stations, a fuel storage area, a tracking station, a transmitter building, headquarters, and a guard house were built south of the launching pads.[26]

The construction of Port Canaveral, a deep-water port located at the south end of the Cape, began in July 1950 and continued through 1952. The Corps of Engineers carried out the dredging of the port. Ships delivered missile components at Port Canaveral and the Navy docked and serviced its tracking ships and missile launching submarines there as well.[27]

On December 31, 1953, the Air Force contracted with Pan American World Services for the operation and maintenance of facilities and equipment at Patrick Air Force Base and Cape Canaveral.[28] Two months later, Pan American chose the RCA Service Company as its primary sub-contractor for communications, photography, and electronic and optical tracking services. The management and direction of range operations remained the responsibility of the Air Force Missile Test Center. Air Force, Army, and Navy

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[24] "Cape History: Establishment of the Eastern Test Range."

[25] Barton and Levy, Architectural and Engineering Survey and Evaluation, 6.

[26] Ibid., 43.

[27] Ibid., 6.

[28] Johnson Controls was awarded the launch base support contract in the late 1980s.

personnel and missile contractor personnel conducted missile checkouts and launchings.[29]

Originally, contractors delivered missile components to Patrick Air Force Base. The contractors assembled the missiles at the base and then transported them by truck to the launching pads at the Cape. Because the bumpy ride to the Cape caused problems for the delicate missile parts, the Air Force decided in the early 1950s to build hangars on the Cape itself in order to assemble the missiles there. This decreased the distance the missiles needed to be carried thereby reducing the wear and tear they were exposed to during transport. Construction of the first hangars at Cape Canaveral started in 1953 with the building of Hangars C and O.[30]

As the missile program progressed at Cape Canaveral, the missiles became more sophisticated and also more powerful. It became apparent that the hangars used to assemble the missiles were dangerously close to the launch pads. In the mid-1950s, with safety considerations in mind, the Department of Defense decided to construct new missile development facilities at the Cape.[31] In early 1952, a "Development Plan for Cape Canaveral" had been prepared by Mr. James H. Deese, Chief of the Equipment Design Branch of AFMTC Facilities Engineering Division and Lt. Hal Snyder, USAF Reserve.[32] Major goals laid out in this plan included separation of launch pads for different project developments, with the northeast coastline reserved for future intercontinental ballistic missile pads and the southeast coastline reserved for light short-range ballistic missiles (see Figure 2). Another aspect of the plan proposed a new industrial area in the western part of Cape Canaveral, safely away from the launch pads.

The Industrial Area

The Industrial Area, located next to the Banana River, midway between the southern and northern boundaries of the Cape, began to take shape in 1954-55. The Industrial Area contained missile

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[29] "Cape History: Establishment of the Eastern Test Range;" John Hilliard, written correspondence with Susan Enscore, 17 May 2008.

[30] Barton and Levy, Architectural and Engineering Survey and Evaluation, 6.

[31] Ibid., 43.

[32] Memorandum from James H. Deese to author, 24 January 2001, 4-5; Documentation and Data Management Branch, John F. Kennedy Space Center, NASA, "Origins and Early Years of the John F. Kennedy Space Center, NASA (Through December 1965)," Kennedy Space Center Historical Monograph Number 4, (Kennedy Space Center, Florida: NASA), 1971, II-19-20.

assembly buildings, shops, chemical storage areas, standards laboratories, heating plants, a fire station, emergency power plants, a cafeteria, and other miscellaneous utilities and structures (see Figure 3). Contractors constructed the first assembly hangar in the Industrial Area, Hangar I, in 1955.[33] Other hangars were eventually built and since the mid-1950s the majority of vehicles launched from the Cape have been assembled at the hangars located in the Industrial Area (see Figure 4). The newly created Industrial Area also contained the Range Control Center, the main operations control facility for the Eastern Range and for Range and public safety.[34]

Later Construction

Development and construction continued at Cape Canaveral during the remainder of the 1950s and 1960s. After 1953, launch facilities were constructed primarily to support the intermediate range ballistic missile and intercontinental ballistic missile programs. A new period of construction began at Cape Canaveral in 1962 when the Air Force began its Titan III program at the installation. Due to safety considerations and area size requirements, Air Force contractors constructed facilities for this program on dredge spoil in the Banana River about a mile from the west side of the Cape. New missile handling technology, engineering, and launching techniques characterized the Titan III Program. Utilizing a concept known as Integrate-Transfer-Launch (ITL), the new Titan III facilities allowed for off-pad assembly of the missile, integration of the boosters, payload checkout and rail transport to one of two launching pads, all while the missile was in a vertical position. The ITL approach enabled the Air Force to obtain a high launch frequency without requiring additional launch pads.[35]

The Titan III facilities, completed in 1964, included two launch complexes (40 and 41), special assembly buildings (including the Vertical Integration Building and the Solid Motor Assembly Building), and the first rail line at Cape Canaveral. Since this period, construction at Cape Canaveral has been limited to modifying various complexes and facilities, providing additional storage, assembly and checkout buildings and a central heating plant in the Industrial area.[36]

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[33] Barton and Levy, Architectural and Engineering Survey and Evaluation, 6.

[34] It was replaced by a new facility, the Range Operations Control Center (now the Morrell Operations Center) on Phillips Parkway in 1995. (Hilliard, written correspondence, 17 May 2008).

[35] Barton and Levy, Architectural and Engineering Survey and Evaluation, 2.

[36] Ibid.

By 1966, activities at Cape Canaveral had reached their peak and in the years following there was a gradual decline in operations. Most of the construction activity had shifted to the Kennedy Space Center in conjunction with NASA's effort to land a man on the moon. A few of the launch complexes and support buildings at Cape Canaveral that had served their purposes and were either not adaptable to other uses or not maintainable for economic reasons were deactivated or put on stand-by. Facilities transferred to NASA during the early 1960s were gradually transferred back to the Air Force for use in their continuing space program activities at the Cape.[37]

By the late 1960s, there were three primary launching zones at Cape Canaveral (see Figure 5). At the point of the Cape were complexes 1, 2, 3, 4, 21/22, and 43. Except for complex 43, which supported weather rocket launches, these complexes had generally been used for various winged missile programs (such as Snark, Bomarc, Matador, Bull Goose, and Mace). Above the point of the Cape were eleven complexes situated in a line along ICBM Road (11, 12, 13, 14, 15, 16, 19, 20, 34, 36, and 37). These complexes supported Atlas, Titan, and Saturn launches. Complexes 5/6, 9, 10, 17, 18, 25, 26, 29, 30, 31, and 32 were located under the point of the Cape. These sites had been built to support Redstone, Jupiter, Navaho, Thor, Blue Scout, Vanguard, Polaris/ Poseidon, Pershing, and Minuteman launches. A new area was emerging near the northern boundary of Cape Canaveral with complexes 40 and 41 for the Titan III.

Missile Testing at Cape Canaveral

Designs for long-range missiles generally fall into two basic categories: aerodynamic cruise, or “winged” missiles; and the more advanced ballistic missiles. Cruise missiles, resembling unmanned airplanes, require oxygen to support engine combustion and are therefore restricted to the earth’s atmosphere. Ballistic missiles, on the other hand, carry their own oxygen source allowing them to travel beyond the earth’s atmosphere. Faster and more effective than cruise-type missiles, ballistic missiles travel in long arcing trajectories before striking their targets. Ballistic missiles themselves are further divided into two basic types: intermediate range ballistic missiles (IRBMs) and intercontinental ballistic missiles (ICBMs). The range of an IRBM can be as great as 1,500 miles while the range of an ICBM can be well over 5,000 miles.

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[37] Ibid.

Early Missile Research and Development

While the Army was beginning to test-launch captured German V-2 rockets at the White Sands Proving Ground in 1946, the Army Air Force (the immediate predecessor of the Department of the Air Force, established in 1947) began funding its first long range missile development studies. In January of that year, engineers from the Consolidated Vultee Aircraft Corporation (Convair) presented the AAF with two design proposals for a missile capable of carrying a 5,000 pound warhead over a range of between 1,500 and 5,000 miles. One design was for a cruise-type missile and the other for a ballistic missile. AAF officials awarded Convair a study contract on April 2, 1946.[38] Headed by the Belgian-born engineer Karl Bossart, the Convair effort became known as Project MX-774.[39] In order to collect the necessary data, Bossart gained permission to build thirteen test vehicles. Funding cutbacks soon forced Bossart to abandon the cruise missile design and concentrate solely on the ballistic missile design. Bossart and his team concentrated their efforts on improving the structural design and performance of the German V-2 rocket but continued funding cutbacks forced the cancellation of the program in July 1947. Even though funding for the project was terminated, the AAF allowed Bossart and his team to use their remaining unexpended funds to complete and flight test three vehicles. These flight tests, conducted at the White Sands Proving Grounds between July and December 1948, validated Bossart's design changes.[40] Later ballistic missile programs benefited from information gained during this project.

In the late 1940s, the United States drastically reduced its defense spending as the nation adjusted back to a peacetime economy. The reductions forced the Air Force to decide between developing either cruise-type long range missiles or ballistic long range missiles. Air Force officials decided to pursue development of the cruise-type missiles on the grounds that this type would become operational sooner than the expected ten-year time frame necessary for the development of an operational ballistic missile.[41] In the late 1940s and early 1950s, the Air Force began to invest heavily in the development of several cruise missiles. These included the Matador, Snark, and Navaho missiles. The Army, meanwhile, continued its work with the V-2.

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[38] Neufeld, Development of Ballistic Missiles, 45.

[39] MX stands for Military Experimental.

[40] Neufeld, Development of Ballistic Missiles, 48-49; Hilliard, written correspondence, 17 May 2008.

[41] Neufeld, Development of Ballistic Missiles, 48.

Early Missile Testing at CCAFS

The Army was the first service to conduct a missile launch at Cape Canaveral. The missile was the Bumper, captured German V-2 rockets with WAC-Corporal second stages. Bumpers No. 1-7 had been previously launched at White Sands Missile Range, but a larger range was needed for the final two Bumpers. The first Cape launch, Bumper No. 8, took place on July 24, 1950, at Complex 3. An Army-General Electric Corporation team launched the rocket under primitive conditions, fueling the rocket directly from tank trucks and using a temporary blockhouse to control the launch.[42] The rocket, whose primary mission was to prove the feasibility of separating stages while in flight, traveled about 190 miles down range. The Army launched Bumper No. 7 from Complex 3 on July 29, 1950, completing the Bumper program.[43]

Aside from the Army Bumper launches, the majority of launches at Cape Canaveral in the early 1950s were Air Force winged missile launches. The first Air Force launch at the Cape occurred on October 25, 1950, when a team launched a Lark interceptor missile. The Lark had first been used by the Navy against Japanese aircraft during World War II. The Air Force's Lark flight lasted less than two minutes and covered only one mile. The Air Force continued to launch Larks at the Cape until July 1953.[44]

The tactical Matador winged missile was the first Air Force missile program to become operational after being tested at Cape Canaveral. It was also the first missile to be successfully tracked by the downrange station on Grand Bahama Island. The Air Force conducted the first Matador launch from the Cape on June 20, 1951. Over the next ten years, the Air Force conducted a total of 286 Matador launches from Complexes 1, 2 and 4 and from the mobile launch area near the ocean.[45]

The Air Force's Snark missile was a surface-to-surface pilotless bomber with a range of over 5,000 miles. It was the first and only long-range intercontinental winged missile. Launched from Complexes 1 and 2 between August 29, 1951 and December 5, 1960, ninety-seven downrange flights occurred. Although the Snark was

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[42] From Sand To Moondust, 9.

[43] Barton and Levy, Architectural and Engineering Survey and Evaluation, 12; Hilliard, written correspondence, 17 May 2008.

[44] "Lark," The Range Quarterly, September 1965, 3. The Air Forces Lark launches at Cape Canaveral served primarily as training vehicles for its Bomarc missile program.

[45] Barton and Levy, Architectural and Engineering Survey and Evaluation, 12.

the first missile to be tracked by the downrange stations at Antigua and Ascension islands, many of the Snark flights were unsuccessful, ending up in the Atlantic Ocean. Despite the many mishaps during testing, the Snark achieved a number of "firsts". These included being the first missile to return and land at Cape Canaveral's skid strip, the first missile to be equipped with a ballistic nose that separated from the missile and fell on its target, and the first missile to use a stellar guidance system.[46] In August 1955, the Air Force began the test phase of its Navaho program at Cape Canaveral. The Navaho launched from Complexes 9 and 10 from November 1956 through November 1958, and was a surface-to-surface missile intended as an intercontinental strategic weapon. It was carried aloft, piggyback fashion, by a liquid-fueled booster. Although the Air Force eventually canceled the program, the Navaho pioneered the development of inertial guidance systems and large rocket engines.

Other winged missiles tested by the Air Force at Cape Canaveral included the Mace, the Bomarc and the Bull Goose/Goose.[47] The Air Force first launched the Bomarc from Complex 4 on September 10, 1952. The defensive winged missile was designed to intercept and destroy enemy aircraft. Bull Goose/Goose testing occurred at Complex 21/22 between March 13, 1957 and December 5, 1958.[48] Also a defensive winged missile, the Bull Goose/Goose was a diversionary missile designed to confuse enemy air and ground forces. The Mace, an improved version of the Matador, was launched from Complex 21/22 between October 29, 1959 and July 17, 1963.

U.S. Ballistic Missiles

In the early 1950s, the U.S. Congress began to reassess the military cutbacks of the late 1940s. As U.S. troops fought in Korea, Congress increased funding for military projects. The Air Force took advantage of the increased funding and initiated a long-range missile study, contracting Convair to carry out the effort. Designated Project MX-1593, this effort later became known as Project Atlas, a ballistic missile development project. The Air Force began funding further studies of the Atlas ballistic missile design in 1952. This funding, however, remained very low compared to the funding for the Air Force's cruise missile programs.[49]

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[46] Ibid., 12, 15.

[47] The missile's designation changed from Bull Goose to simply Goose in May 1958.

[48] Barton and Levy, Architectural and Engineering Survey and Evaluation, 15.

[49] Neufeld, Development of Ballistic Missiles, 241.

While the Air Force Atlas ballistic missile program proceeded slowly, the Army was making significant progress in ballistic missile development. The Army had moved its team of German scientist working at White Sands to the Redstone Arsenal in Huntsville, Alabama in 1950. This team developed the Redstone missile. The Army began testing the Redstone at Cape Canaveral in 1953, the first launch occurring on August 20 at Complex 4. This was the first ballistic missile launch at Cape Canaveral. The Army continued launching Redstones at Cape Canaveral throughout the mid-1950s. In 1956, the Redstone became the first ballistic missile to be deployed in the field by U.S. troops and in 1958 the United States placed the Redstone in the North Atlantic Treaty Organization (NATO) arsenal.[50]

Although the Redstone was a ballistic missile, it had a maximum range of only 200 miles and served merely as an extension of the Army's artillery. The Department of Defense desperately desired a long-range missile that could reach Soviet targets when launched from U.S. soil. Early ICBM designs, however, called for giant, impractical missiles. These designs were based on the thrust requirements necessary to loft the heavy atomic warheads being produced at the time. Even if such a missile could be produced, considerable gains in guidance system technology would be necessary to make the missile accurate enough to be effective. Several important developments in the early 1950s, however, significantly impacted on ballistic missile design requirements. The first was the detonation of the world's first thermonuclear device by the United States in 1952. This event paved the way for development of the powerful hydrogen bomb. Soon after the detonation, the Atomic Energy Commission (AEC) predicted that the production of smaller nuclear warheads with tremendous destructive potential would soon be feasible. Smaller, yet more powerful warheads would solve many of the problems associated with missile weight and would also eliminate the need for pinpoint accuracy. This news, combined with intelligence reports indicating that the Soviet Union was making significant progress in developing both long-range missiles and thermonuclear warheads, prompted a reexamination of the U.S. strategic missile programs.

The Air Force convened a panel of leading U.S. scientists in 1953 to examine the Snark, Navaho, and Atlas missile programs. Known as the Teapot Committee, the panel's report, submitted on

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[50] "Redstone," The Range Quarterly, September 1965, 7. In the mid-1960's, the Army replaced the Redstone missile with the Pershing missile. The Army tested the 100-400 mile-range Pershing missile at Cape Canaveral between February and April 1963.

February 10, 1954, contained recommendations for relaxing performance requirements for long-range missiles (based on the new, lightweight, high yield thermonuclear weapons) and accelerating the development of the Atlas ICBM.[51] These recommendations received the approval and support of high-ranking civilian and military leaders during the following months. Air Force officials, and in particular Trevor Gardner, Special Assistant for Research and Development, began campaigning vigorously to convince Congress and the President of the urgency of ICBM development. These efforts paid off on September 8, 1955 when President Eisenhower assigned highest national priority to the ICBM development program.

Air Force officials originally hoped to achieve operational capability with the Atlas by 1960. As a hedge against failure in the Atlas program, however, the Air Force initiated a second ICBM development program in 1955. This alternate ICBM became known as the Titan. By 1958, the Air Force began funding development of yet another ICBM, the Minuteman. The three-staged Minuteman was a solid-fueled ICBM designed for instantaneous launch from a heavily protected underground silo.

As the pace of the Air Force ICBM program quickened, intelligence reports indicated that by 1960 the Soviet Union would likely have a number of operational ICBMs armed with nuclear warheads. Fearing the U.S. would not be ready to match that threat, Department of Defense officials decided that an IRBM should be developed and based in Europe to act as a stopgap measure until a sufficient number of American ICBMs became operational. After it was concluded that an IRBM with a 1,500 mile range could be developed in a relatively short time, the Joint Chiefs of Staff granted approval in 1955 for two IRBM programs - the Air Force Thor IRBM program and the Army/Navy Jupiter IRBM program. Both programs advanced simultaneously, in direct competition with each other.[52]

IRBM Programs

The Army was the first service to test launch an IRBM at Cape Canaveral. This occurred on March 14, 1956, when a modified Redstone with Jupiter components (known as Jupiter A) lifted off the pad at Complex 6. The first Jupiter IRBM launch occurred at Cape Canaveral one year later on March 1, 1957. The Army conducted a total of 65 Jupiter launchings through January 22,

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[51] Neufeld, Development of Ballistic Missiles, 99-103.

[52] Ibid., 143-148. The IRBM programs were assigned equal priority with the ICBM program in January 1956.

1963 at Launch Complexes 5/6 and 26.[53] The Jupiter became operational in 1960. Although developed by the Army, it was the Air Force that actually gained operational responsibility for the weapon system. This situation came about in November 1956 when Secretary of Defense Charles Wilson issued a memorandum that divided responsibilities for research and development of ballistic missiles among the armed services. Wilson restricted the Army to developing weapons with ranges of 200 miles or less. At the same time, Wilson assigned sole responsibility for the development and deployment of IRBMs and ICBMs to the Air Force. The Navy received responsibility for developing ship-based IRBM systems.[54] The Army completed the development of the Jupiter IRBM and then turned it over to the Air Force for deployment.[55] The Air Force had operational Jupiter IRBM squadrons in Italy and Turkey by mid-1962.

The Navy initially took part in the development of the Jupiter IRBM with hopes of converting the missile for use on submarines. However, the Navy eventually determined that the liquid fuels of the Jupiter were too volatile and unpredictable to be carried aboard a submarine. In 1956, the Navy withdrew from the Jupiter project and began developing the solid-fueled Polaris IRBM.[56] The Polaris was designed to be launched from submarines whether the submarine was surfaced or submerged. The Polaris program began at Cape Canaveral in 1957, with the construction of Launch Complex 25. While construction of Complex 25 was underway, the Navy conducted its first Polaris launch at the Cape at Complex 3 on April 13, 1957. The first launch at Complex 25 occurred on April 18, 1958.[57] The Polaris became operational in 1960, although the Navy continued test launching versions of the missile at Cape Canaveral through the 1970s. In 1968, the Navy began testing its second generation Poseidon Ship-Launched Ballistic Missile (SLBM) at Cape Canaveral and in 1977 the Navy began its Trident SLBM program at Cape Canaveral.[58]

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[53] Ibid; Hilliard, written correspondence, 17 May 2008.

[54] Barton and Levy, Architectural and Engineering Survey and Evaluation, 17.

[55] The Army did continue to develop the Jupiter as a space booster.

[56] Neufeld, Development of Ballistic Missiles, 143-148.

[57] Chronology of the Joint Long Range Proving Ground, Florida Missile Test Range and Atlantic Missile Range, 1938-1959, History Office, 6550th Air Base Group, Air Force Eastern Test Range (Air Force Systems Command, 1975), 105, 111.

[58] In order to service its missile launches, the Navy built a complex at the south end of the Cape which included launch complexes, missile assembly and checkout facilities, administrative buildings, and a Navy pier facility at Port Canaveral.

The Air Force Thor IRBM program began at Cape Canaveral in 1956, when the Air Force initiated construction of Complex 17 (Pads A & B). The first Thor launch occurred at Cape Canaveral on January 25, 1957, at Complex 17. Unfortunately, the missile exploded and burned on the pad. Three more mishaps followed until finally, on September 20, 1957, the Thor completed a fully successful test launch. The Air Force conducted the research and development testing phase of the Thor program at Cape Canaveral and the operational testing phases of the program at Vandenberg Air Force Base, California. Such was the case with the Air Force Atlas, Titan, and Minuteman ICBM programs as well. The Thor became operational in May of 1960. By the end of that year, the Air Force had deployed four squadrons of 60 missiles in England with the Royal Air Force. The Air Force began to phase out these Thor squadrons in 1962 and 1963 as its Atlas and Titan ICBM sites became operational. Because of its reliability and versatility, the Thor continued in service as the booster for a wide variety of space missions.[59]

ICBM Programs

At the same time the Air Force was developing its Thor IRBM it was also making significant headway in its ICBM programs. The Atlas research and development testing program began on June 11, 1957, at Cape Canaveral. The Air Force conducted Atlas test launches at Complexes 11, 12, 13, and 14 through 1962. During the course of the Atlas program, the Air Force tested several models of the missile. These models were designated series A through F. The Air Force eventually stationed the D, E, and F models, equipped with warheads and inertial guidance systems, at bases around the country as part of the U.S. national defense arsenal. At one point, a total of 129 Atlas ICBMs were on strategic alert. The Air Force phased out its Atlas arsenal in 1964 and 1965, following the development of the Titan II and Minuteman ICBMs. Similar to the Thor, the Atlas also remained in service as a booster for America’s manned and unmanned space missions.

The Air Force first tested its Titan ICBM at Cape Canaveral on February 6, 1959. Twenty of the first twenty-five Titan launches were completely successful. The Air Force declared the Titan ICBM operational in December of 1961 and by the end of 1962, six Titan squadrons were operational at five western Air Force bases. The first launch of the Air Force’s second generation Titan, the Titan II, occurred on March 16, 1962, at Cape Canaveral. The Titan II, America’s largest ICBM, was capable of carrying a heavier load than Titan I, used an inertial guidance system

[59] From Sand to Moondust, 15; Hilliard, written correspondence, 17 May 2008.

rather than a radio guidance system, and had the capacity to be launched from a silo. The Air Force declared the Titan II operational in December of 1963. Titan II was deployed at three Air Force bases and was also used as the booster for Project Gemini. The Air Force tested both Titan I and II missiles at Complexes 15, 16, 19 and 20. The Air Force also developed a Titan III, but this missile was not a weapon system. It was developed as a standardized launch vehicle for space programs. The Air Force first launched its Titan IIIA vehicle on September 1, 1964. The Air Force used Complexes 40 and 41 (Complex 41 is located at the Kennedy Space Center) for the Titan III development program.[60]

Liquid propellants fueled most of the early weapons systems developed at Cape Canaveral. The Minuteman, the first multi-stage solid-fueled ICBM, was designed around the concept of instantaneous response to enemy attack. It was lighter, smaller, simpler and less expensive than the Atlas and Titan ICBMs. The Air Force eventually developed and test launched three versions of its Minuteman ICBM. Complex 31 hosted the first Minuteman launch on February 1, 1961. The Air Force test launched its Minuteman I, II and III ICBMs at Complexes 31 and 32 at Cape Canaveral through December 14, 1970.[61] The Air Force first deployed Minuteman ICBMs at its bases in 1962. These missiles eventually became the backbone of the nation’s strategic land-based nuclear missile force.

Beginnings of the U.S. Space Programs

The official beginnings of the U.S. space program can be traced back to 1955, when President Eisenhower announced that the United States would launch a small, unmanned Earth-circling scientific satellite as part of the nation’s participation in the International Geophysical Year (IGY).[62] While planning for the IGY late in 1954, the International Scientific Committee discussed satellite vehicles as a way of obtaining information about the upper atmosphere. The IGY provided a perfect opportunity for the United States to start a satellite program that would not appear to be motivated by military considerations. In reality however, military leaders in the United States were extremely interested in developing a military space program. Although the Air Force, Army, and Navy all had been conducting upper air research programs of varying magnitude, none of the

[60] Ibid., 19 and 17 May 2008.

[61] From Sand to Moondust, 20.

[62] The IGY extended from July 1957 to December 1958.

services had initiated any major efforts to start a satellite program by the early 1950s.
President Eisenhower's announcement concerning the IGY prompted all three U.S. armed services to begin devising plans for a satellite program. By April, three separate plans had emerged. The first was a joint effort by the Army and Navy designated Project Orbiter. This plan called for placing a simple uninstrumented satellite into orbit utilizing an Army Redstone booster. A second plan by the Navy, eventually designated Project Vanguard, involved using a Navy Viking rocket as the first-stage of a three-stage rocket. The Air Force's plan recommended using an Atlas coupled with an Aerobee-HI second stage.

Faced with these three plans, the Department of Defense set up a special advisory group to review the proposed satellite programs and to make recommendations. Although favoring the use of the Atlas, the committee eventually decided that the Navy program had the best chance of placing the most useful satellite into orbit within the IGY without interfering with the priority of ballistic missile development. As a result, the Navy was given permission to proceed with its Project Vanguard.

Even after the Department of Defense advisory group announced their official support for the Vanguard program, the Army continued to push its own proposed satellite program. Although the proposal was continuously rejected, the Army Ballistic Missile Agency continued to claim it could launch a satellite on only four months notice. The Army's persistence would eventually pay off.

In August 1957, the Soviet Union announced that they had successfully launched a multi-stage long-range ballistic missile that had reached a "very high, unprecedented altitude."[63] The Soviets followed this launch with an even more impressive feat. On October 4, 1957, the Soviets shocked the world by placing Sputnik, the first man-made satellite, into orbit with one of their rockets. They quickly followed this launch with another the following month. On November 3, a Soviet rocket placed the 1,120-pound Sputnik 2 satellite, carrying a live dog, into orbit. The Sputnik launches focused public attention on the United States' own fledgling missile and space programs. Reacting to the public furor created by the Sputnik launches, Congress increased funding for ICBM development while the Department of Defense pushed hard to match the Soviet feat by placing its own satellite into orbit.

[63] Carl Berger and Warren S. Howard, History of the 1st Strategic Aerospace Division and Vandenberg Air Force Base, 1957-1961, (Vandenberg Air Force Base, California: Headquarters, 1st Strategic Aerospace Division, April 1962), 8.

While the Soviets were successfully placing satellites into orbit, the Navy satellite program was experiencing many problems. The Vanguard launch vehicle blew up on its pad several times during a string of failed launch attempts. This was all the more embarrassing for the United States given the spectacular success of the Sputnik launches. While the Navy worked frantically to conduct a successful launch, the Army beat them to it. After the Sputnik launches, the Secretary of Defense gave approval to the Army to proceed with its satellite program. Eighty-four days later, on January 31, 1958, an Army team succeeded in placing the first U.S. artificial satellite, Explorer I, into orbit using a modified Redstone missile known as Juno I. This historic launch occurred at Complex 26. The Vanguard team finally succeeded in placing a satellite into orbit on March 17, 1958. The three-pound Vanguard I satellite, launched from Complex 18, studied temperatures and upper atmosphere conditions and also revealed the earth to be slightly pear-shaped.[64]

U.S. Military Space Program

The Vanguard and Explorer launches were early efforts to place fairly primitive scientific satellites into orbit. The Department of Defense, however, gained valuable experience in satellite launch techniques as a result of these early efforts. Eager to build upon that experience, Department of Defense officials soon began planning the development of satellites that could be used specifically for military purposes. Although there had been interest among the armed services in developing reconnaissance satellites as far back as 1945, several obstacles delayed their development. Chief among these were the considerable technological challenges posed by achieving and maintaining orbit and the problems of data transmission.

Initially, the development of military satellites did not receive a high priority because the Department of Defense focused its attention on the development of operational long range missiles. By the mid-1950s, however, when it became clear that the Soviet Union would soon have numerous operational ICBM sites posing a threat to the security of the United States, American leaders quickly realized the importance of identifying the characteristics and location of those weapon systems. On March 1, 1954, the Research and Development Corporation (RAND) produced

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[64] C.W. Scarboro, Twenty Years in Space: The Story of the United States' Spaceport (Cape Canaveral, FL: Scarboro Publications, 1969), 155.

Report R-262, Project FEEDBACK, that recommended the Air Force develop a surveillance satellite program.[65]

In response to this study, within a year the Air Force began calling for proposals from industry for the development of a photographic reconnaissance satellite. Two basic types of satellite systems were subsequently proposed. One was a "non-recoverable" radio-relay reconnaissance system in which television cameras aboard a satellite would photograph ground targets, store the imagery on tape, and then relay the images to ground receiving stations when the satellite passed close enough overhead. The second type of satellite featured a "recoverable" system in which a capsule loaded with exposed film would be ejected from its satellite and return to earth where it would then be recovered. The development plan was approved in July 1956 and the Air Force awarded the Lockheed Corporation a contract to develop both types of satellites in October 1956. The project became known as WS-117L (Weapon System-117L).[66]

By 1958, the National Security Council assigned highest priority status to the development of an operational reconnaissance satellite. In November of that year, the Department of Defense announced plans for its WS-117L program, revealing that it would consist of three separate systems: DISCOVERER, SENTRY (later called SAMOS), and MIDAS. The first two were reconnaissance systems and the latter was the nation's first ballistic missile early warning satellite system. The Air Force conducted launches under these programs, using Thor and Atlas boosters coupled with various upper stages (primarily the Agena), throughout the 1960s and beyond. All of the DISCOVERER and SAMOS launches occurred at Vandenberg Air Force Base. Cape Canaveral supported the first two MIDAS launchings on February 26 and May 24, 1960.[67]

The U.S. military satellite launchings did not go unnoticed in the Soviet Union. On several occasions the Soviets complained bitterly about the satellites. In light of statements by the Soviets on the illegality of such activities and the increasingly credible threat to shoot U.S. reconnaissance satellites down, officials in the Kennedy administration decided to drastically curtail any official publicity concerning U.S. military satellite programs. By 1962, all military launches were classified as secret. The national reconnaissance effort continued although

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[65] William E. Burrows, Deep Black: Space Espionage and National Security (New York: Random House, 1986), 83; Hilliard, written correspondence, 17 May 2008.

[66] Burrows, Deep Black, 84. The WS-117L project was code-named Pied Piper.

[67] Hilliard, written correspondence, 17 May 2008.

henceforth it was conducted under the highest degree of official secrecy.[68] Government officials hoped that the black-out of these activities would make it much harder for the Soviets to pick out the military satellites from among the various other non-military application satellites the United States was launching.[69] In addition, the Kennedy administration hoped that if the Soviet Union was not unnecessarily embarrassed in front of the other nations of the world, Soviet officials would not complain as loudly about U.S. satellite reconnaissance activity.[70]

By the mid-1960s, reconnaissance satellites were yielding a regular supply of photographs to officials in the military services and the CIA, allowing them to stay up to date with the latest Soviet military developments. By revealing that the Soviets did not have as many ICBMs deployed as U.S. officials had previously thought, reconnaissance satellite photographs were greatly responsible for dispelling fears of the much publicized "missile gap."[71] Reconnaissance satellites also proved invaluable in monitoring compliance with international arms treaties such as the 1963 Nuclear Test Ban Treaty and the Strategic Arms Limitation Treaty (SALT).[72]

The United States has also launched other types of satellites that have military applications. These include defense communication, weather, and navigational satellite systems. Some of the important non-reconnaissance military satellite launches of the late 1960s and 1970s include the Initial Defense Satellite Communication System (IDSCS) and the Defense Satellite Communications System (DSCS II and DSCS III), the Tactical Communications Satellite system (TACSAT I), the Fleet Satellite Communications system (FLATSATCOM), the Defense Meteorological Satellite Program (DMSP), and the NAVSTAR Global Positioning

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[68] After the launch of SAMOS 5 in December 1961, officials would no longer even admit the existence of the SAMOS project (Jeffrey T. Richelson, The United States' Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program (New York: Harper & Row, 1990), 53).

[69] Ibid., 65.

[70] Burrows, Deep Black, 142.

[71] President Kennedy used the "missile gap" argument as a campaign issue in the presidential election of 1960. He charged that the Soviet Union was gaining a strategic advantage over the United States in ICBMs. In 1961, photographs recovered from the DISCOVERER satellites reduced the estimate of Soviet ICBMs from the hundreds previously thought to ten to twenty-five, thereby dispelling the missile gap notion (Richelson, The United States' Secret Eyes in Space, 349).

[72] The Nuclear Test Ban Treaty, signed by the United States, Great Britain and the Soviet Union, prohibited nuclear testing in the atmosphere, in space, and under water.

System (GPS) program. Most of the above satellites have been launched from Cape Canaveral or the Kennedy Space Center. The DMSP as well as numerous early navigational satellites have been launched from complexes at Vandenberg Air Force Base.

The military space program played a crucial role in the nation's strategic efforts during the Cold War. Satellites have kept the United States abreast of the qualitative and quantitative characteristics of the weapons systems deployed by potential adversaries. This has helped the leaders within the U.S. government more accurately assess potential threats to the national security and has guided them in their policy deliberations. Perhaps more importantly, the military space program made a significant contribution to the maintenance of international stability, particularly between the two nuclear superpowers of the Cold War era. Arms control resolutions and treaties would have carried little weight had there not been satellites capable of accurately monitoring the degree of compliance among the signatory nations. In addition, by virtually eliminating the possibility of a surprise attack on the United States, reconnaissance satellites have dramatically reduced the possibility that any nation might be tempted to launch such an attack.

U.S. Unmanned Civilian Space Program

Besides spawning the nation's military space program, the early Explorer and Vanguard launches signaled the beginning of the U.S. civilian space science program as well. From these pioneering scientific launches evolved programs to study the earth, the solar system, interplanetary space, the Moon, other planets and their moons, the galaxy, and ultimately, the universe. Besides enormously expanding our pool of scientific knowledge, these efforts greatly contributed to the nation's effort to send men safely to the moon and back. Information gained from the various U.S. space science programs also has been applied toward practical ends, resulting in numerous application satellite programs. These application satellite programs have had a profound effect on the lives of a large proportion of the world's population.

NASA is the primary Federal agency responsible for civilian space programs. Other agencies, such as the National Science Foundation, the Department of Defense, and the Smithsonian Astrophysical Observatory, have specialized or complementary roles. After the Soviet Sputnik launches, President Eisenhower assigned temporary responsibility for the U.S. space program to the Department of Defense. The Department of Defense subsequently established the Advanced Research Projects Agency (ARPA) in

February of 1958. ARPA became, in essence, the first U.S. space agency. The Eisenhower administration, however, envisioned this as only a temporary measure. The president was hoping to reach an agreement with the Soviet Union that would limit the use of outer space to peaceful purposes. Realizing that a U.S. space agency headed by the military would jeopardize this goal, Eisenhower pushed for the creation of a civilian space agency.[73]

The National Aeronautics and Space Act that became law on October 1, 1958, established NASA as the primary U.S. space agency responsible for developing and carrying out a national space program. NASA was created with the expressed intent that its space program be directed toward peaceful pursuits. The new civilian agency was to carry out aeronautical and space activities except those associated with defense, which were the responsibility of the Department of Defense. In anticipation of conflicts between NASA and the Department of Defense, provisions were made for mediation between the two via the President and a newly formed National Aeronautics and Space Council.[74]

In August of 1961, the National Aeronautics and Space Administration (NASA) and the Department of Defense chose a section of Merritt Island (across the Banana River, three miles west from Cape Canaveral) as the launch center for the Manned Lunar Landing Program. This would be the site of the John F. Kennedy Space Center, owned and operated by NASA. During the period of the land acquisition and development, NASA built and modified a number of existing Air Force launch and support facilities at Cape Canaveral to carry out manned and unmanned space programs.[75]

Almost immediately, NASA initiated a National Launch Vehicle Program aimed at eliminating the proliferation and duplication of orbital launch vehicles. Consequently, five launch vehicle families evolved. These included the Scout, the Thor (which eventually evolved into the Delta), the Atlas, the Titan, and the Saturn vehicles. Separate complexes at Cape Canaveral supported launchings of these space boosters. The successful launch vehicle program enabled NASA and the Department of Defense to turn to each other for launch services whenever a certain payload better

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[73] Congress, House, Committee on Science and Technology, Subcommittee on Space Science and Applications, United States Civilian Space Programs, 1958-1978, report prepared by Science Policy Research Division (Marcia S. Smith and others), Congressional Research Service, Library of Congress, 97th Congress, 1st sess., January 1981, Committee Print, 46-48.

[74] Ibid., 52.

[75] "Master Plan of the Cape Canaveral Missile Test Annex," 1.

fit the other agency's launch vehicle, regardless of who sponsored the launch vehicle.[76]

NASA's civilian unmanned space program consisted of both science and application satellite and space vehicle programs. Throughout most of the 1960s, these programs were under the direction of the NASA Office of Space Science and Applications. A reorganization within NASA in 1972 resulted in the separation of the science and application satellite programs with each given its own office headed by an associate administrator.[77]

Many of the missions in NASA's space science program have been directly related to physics and astronomy. Although some of these missions have been sub-orbital, involving sounding rockets and balloons, and others have traveled as far as the Moon, the majority of NASA's physics and astronomy missions have been Earth orbital. The orbital missions have been especially rewarding to scientists because they allow measurements to be taken of phenomena well above the reach of sounding rockets or balloons. Orbital missions also have helped revolutionize astronomy by placing telescopes above the distortion caused by atmospheric turbulence and electromagnetic, infrared, and short-wave radiation.[78] Explorer spacecraft and several more complex orbiting observatories, such as the Orbiting Solar Observatory (OSO), the Orbiting Astronomical Observatory (OAO), the Orbiting Geophysical Observatory (OGO) and the High Energy Astronomy Observatory (HEAO), provide NASA with its principal means of conducting long-term automated investigations of the Earth, interplanetary space in close proximity to the Earth, Sun-Earth relationships, and astronomical studies of the Sun, stars, and galaxies.[79] Explorer missions, many of them undertaken with a significant degree of international cooperation, have been launched from both Cape Canaveral and Vandenberg Air Force Base using a variety of launch vehicles. Launches in the Explorer series began in 1958 and have continued into the 1990s. NASA launched most of its orbiting observatories from Cape Canaveral complexes in the 1960s and 1970s; however a few OGOs were launched from Vandenberg AFB between 1965 and 1969.[80]

Major NASA programs involving investigations of distant interplanetary space, the Sun, the Moon, and the planets include

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[76] Ibid., 184.

[77] Ibid., 718.

[78] Ibid., 721.

[79] Ibid., 723.

[80] Hilliard, written correspondence, 17 May 2008.

Helios, Pioneer, Pioneer-Venus, Ranger, Surveyor, Lunar Orbiter, Mars, Mariner, Viking, and Voyager.[81] In supplying scientists and technicians with invaluable information and images, the spacecraft associated with these programs have dramatically increased our knowledge and understanding of our solar system and beyond.

Besides purely scientific programs, the U.S. unmanned space program has also encompassed a multitude of application satellite programs. Too numerous to list here in detail, these application programs include communication satellites, meteorological satellites, earth resources and environmental monitoring satellites, ocean sensing satellites, geodynamic satellites, and navigation satellites. Application satellites have had a tremendous impact on modern life. They have linked together remote areas of the earth, exerted a lasting impact on the growth and application of the science of meteorology, and provided numerous new ways to examine and map the Earth and its oceans.[82] Also, there has always been a close correlation between civilian and military application satellites, especially for communications, weather and geodetics. Application satellites characterized as “military” often provide useful information to the civilian sector while “civilian” satellites, in turn, often furnish important information to the military as well.[83] The U.S. application satellite programs, combined with the nation’s space science programs, have revolutionized the way we see our world and the way in which we live in it.

U.S. Manned Space Program

In April of 1961, Russian cosmonaut Yuri Gagarin rode the Vostock I into an orbit around the earth, becoming the first man to do so. This achievement shook American officials into action. On May 25, 1961, in a special message to Congress, President Kennedy stated that the United States “... should commit itself to

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[81] For detailed descriptions of these programs, see United States Civilian Space Programs, 1958-1978.

[82] For information on specific civilian application satellite programs see United States Civilian Space Programs: Volume II, Application Satellites prepared for the Subcommittee on Space Science Applications of the Committee on Science and Technology, U.S. House of Representatives, 98th Congress, 1st session, May 1983.

[83] For example, the Department of Defense's DMSP satellites regularly provide weather data to the National Oceanic and Atmospheric Administration (NOAA). Conversely, in March 1984, the NOAA's Landsat 4 earth resources satellite helped Department of Defense officials detect a Soviet ballistic missile-firing submarine testing equipment designed to smash through Arctic ice prior to underwater missile launch (see Burrows, supplemental photos).

achieving the goal before this decade is out, of landing a man on the Moon and returning him safely to the earth."[84] Public support was widespread and Congress heartily endorsed the measure. NASA was responsible for carrying out the ambitious goal.

The American manned space program was divided into three phases: the Mercury, Gemini and Apollo programs. Cape Canaveral supported all of these phases.

Project Mercury

The goals of Project Mercury were to demonstrate that it was possible for a man to tolerate what it would take to send him into space and bring him back. These included withstanding the acceleration of rocket launches, adapting to long periods of weightlessness, and then withstanding the high deceleration period during re-entry. Project Mercury had two parts, a sub-orbital stage and a manned orbital stage. During the first stage, NASA launched the chimpanzee, Ham, on a sub-orbital flight aboard a Mercury/Redstone vehicle on January 31, 1961. Other test launches utilizing primates followed. Alan Shepard became the first American man in space on May 5, 1961, when he rode aboard a modified Redstone rocket. Virgil Grissom's flight followed on July 21, 1961.[85]

John Glenn became the first American man to successfully accomplish a manned orbital flight mission. He circled the earth three times aboard Mercury/Atlas (MA-6) on February 20, 1962. Gordon Cooper's 22-orbit flight, ending on May 15, 1963, concluded Project Mercury. It was the fourth manned mission. NASA launched the first two manned Mercury flights from Complex 5/6, and the remaining four from Complex 14.[86] These flights were controlled from the Mercury Mission Control Center. Located on what became Mission Control Road at Cape Canaveral, construction for this facility began in 1957. The center took over flight control when the rocket left the pad and maintained it through splashdown. This function was later transferred to the Johnson Space Center in Houston in 1965 supporting the Gemini, Apollo, and Space Shuttle programs.[87] The whole Mercury program lasted 55 months and led directly to Project Gemini.[88]

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[84] From Sand to Moondust, 29.

[85] Barton and Levy, Architectural and Engineering Survey and Evaluation, 28.

[86] Ibid., Appendix 7.

[87] Man In Space: Study of Alternatives (United States Department of the Interior, National Park Service, 1987), 35; Hilliard, written correspondence, 17 May 2008.

[88] Man In Space, 28.

Project Gemini

NASA publicly announced Project Gemini on January 3, 1962. The goal of Project Gemini was to perfect space rendezvous and docking techniques and to attempt extravehicular walks in space. The successful completion and mastering of these operations was necessary in order to move on to the next step of landing men on the moon and then recovering them. Sophisticated manned space flight was mastered during this project.

NASA used a modified Titan II as the space booster for Project Gemini and a Mercury capsule - twice the size of earlier capsules, was used to accommodate two astronauts. The first Gemini launch took place on April 8, 1964, from Complex 19. The first Gemini manned flight took place on March 23, 1965. There were a total of ten manned Gemini flights, placing 20 astronauts into orbit. These flights allowed the astronauts to conduct sophisticated maneuvering exercises and return back to earth safely.[89]

Project Apollo and Beyond

The goal of Project Apollo was to send a three-man spacecraft into orbit around the Moon, land two of the astronauts on the Moon while the third continued to orbit, return the two men back to the orbiting spacecraft and then return all the men safely back to earth. NASA announced on January 9, 1962, that the Saturn V rocket would be the launch vehicle. The Saturn V was a huge rocket standing 363' tall (with the Apollo spacecraft) and capable of generating 7.5 million pounds of thrust.[90] NASA divided Apollo into two phases: earth orbital (unmanned and manned) and lunar. Missions were designed to test spacecraft launch vehicles, equipment and crew procedures. Tragedy struck on January 27, 1967, when an oxygen fire in the Apollo spacecraft at Complex 34 took the lives of astronauts Virgil Grissom, Edward White and Roger Chaffee, the first casualties of the U.S. space program.

Despite the tragedy, the Apollo program continued. The first Saturn V test flight took place on November 9, 1967, with the launch of Apollo 4 from Complex 39. The first manned Apollo launch took place on September 26, 1968, when Apollo 7 put three astronauts into earth orbit from Complex 34 using a Saturn IB rocket. The first lunar orbiting occurred during Apollo 8 on

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[89] Ibid., 30.

[90] From Sand to Moondust, 29.

December 21, 1968 using a Saturn V from Complex 39. Finally, on July 20, 1969, Commander Neil Armstrong became the first man ever to set foot on the moon during the Apollo 11 mission. Six additional moon missions followed. Apollo 17, launched on December 7, 1972, was the last mission in the series. The Apollo launches took place at Complex 34 at Cape Canaveral and Complex 39 at the Kennedy Space Center.[91]

Three other manned Apollo space missions occurred from Kennedy Space Center to the Skylab Station. The Skylab mission began on May 14, 1973, and involved placing a large inhabitable structure into orbit around the earth for use in collecting scientific data. Apollo-Soyuz was a cooperative project between the Americans and the Russians involving the docking of two manned spacecraft in space. NASA launched this project from Complex 39 at the Kennedy Space Center. NASA first launched the Space Shuttle, the world's first reusable spacecraft, from Pad A at Complex 39 on March 12, 1981. Complex 39 continues to support Space Shuttle launches from Pad A and Pad B.[92]

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[91] Ibid.,; Hilliard, written correspondence, 17 May 2008.

[92] From Sand to Moondust, 32.

HISTORY OF COMPLEX 21/22

Construction began on Launch Complex 21/22 in 1956 on a previously selected location near the eastern-most point of Cape Canaveral Air Force Station. Sited on Lighthouse Road, the complex was placed slightly northeast of Hangar C and the Cape Canaveral lighthouse at the road's intersection with Camera Road B. The complex is accessed from Lighthouse Road, and the main launch facility faces east-southeast towards the Atlantic Ocean (see Figures 6 and 7).

Complex Construction and Development

Table 1 summarizes the construction phases for Complex 21/22.

Table 1. Complex 21/22 construction phases.

Phase No.	Construction completion date and description	Facilities constructed during phase
Phase I	Original 1957 construction of the Pad 22 site.	Launch pad 22 Launch pad 22 power outlets, safety enclosure, and lighting Revetment
Phase II	1958 construction adjacent to and encroaching on the existing Pad 22 site; extended the existing Pad 22 site by 380 feet to the southwest.	Launch pad 21 Launch pad 21 lighting, power receptacle posts, and camera pads (the latter in 1959) Underground utility room (Building 5914) and utility tunnel Blockhouse (Building 5951) Blockhouse transformer vault (Building 5952), switching pad (Facility 5953), and septic tank and drain field (Facility 5964) Communication trench Two sentry houses (removed)
Phase III	1960 additions to the existing Complex 21 site; all phases subsequently consolidated into Complex 21/22 which occupies the combined Phase 1 (Pad 22) and Phase II (Complex 21 plot) sites.	Launch building (Building 5912) Control house (Building 5959) Transformer vault (Building 5961) and transfer switch

The original plan for the site consisted of dual launch pads (No. 21 and No. 22). Construction began in 1956 and, as all missile program construction at Cape Canaveral, was conducted by the U.S. Army Corps of Engineers from the Jacksonville District. The northernmost pad (No. 22) was constructed and used first; it was accepted as complete by the Air Force on February 26, 1957.[93] The initial complex provided little in the way of facilities except for a poured concrete launch pad, a blast revetment, camera pads, and power hookups. The first missile launches from launch pad 22 consisted of bringing in the missile on a mobile launcher, which was tied down to the pad. Cables and other equipment were attached for system check-out and launch preparation, and the launch control was provided by a van parked on the far side of the sandbag revetment (see Figures 8, 9, and 10). A periscope behind the revetment provided a visual check of the launch pad (see Figure 11).

Although Bull Goose test flights were being launched from pad 22 as early as March 13, 1957, a pad 21 and the blockhouse (No. 5951) for the complex were not constructed until 1958, along with cable trays to the pads. Other activity at the site in 1958 included the construction of a ramp for the portable missile shelter to roll over cables, and a concrete trench with steel plate covers, both in the pad 22 area. Two sentry houses were constructed at the north and south ends of the complex in November 1958, and an electrical emergency power plant was added. Also in place by the end of that year was the underground utility room (No. 5914) located between pads 21 and 22. Five camera pads were constructed in November 1959.[94]

The Mace missile testing program at Cape Canaveral was assigned to pads 21 and 22. The new use required significant changes in the facilities on site. Research for this project was unable to determine when this assignment took place – it is possible the bulk of the 1958 construction was in anticipation of the Mace program's use of the complex. Construction began in 1959 on a launch building (No. 5912) with two elevated launching bays for the Mace B missile (see Figure 12). This structure was accompanied by a new two-story auxiliary control building (No. 5959) (see Figures 13 and 14). The previous configuration of pad 21 was eliminated as that was the location selected for these two

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[93] Mark Cleary, "The 45th Space Wing: Its Heritage, History & Honors, 1950-1995," (Patrick Air Force Base, FL: 45th Space Wing History Office, 1996), 50.

[94] "Real Property Accountable Record for Complex 21/22," Cape Canaveral Air Force Station, Florida.

newest buildings.[95] Construction was completed in the first half of 1960, and the hard site was first used on July 11, 1960.

Facilities at the complex by 1960 included:[96]

1402A [05951] - Blockhouse (Blockhouse) ($270,781.00).
1402 B - launching pad 22 ($16,584.00).
1402 C - launching pad 21 (no cost given).
1402 D [05913] - revetment (Complex 22 Revetment) ($20,457.00).
1402 E [05914] - underground vault (Utility Room) ($55,353.00).
1402 F - security building (south) ($2,241.00)
1402-G [moved to 55220] - security building (north) ($2,242.00)
1402 H [04215 warning system] - compressed air plant building ($536.00).
1402 J [05959] - auxiliary control building (Control Building) ($73,691.00).
1402-K [05912] - Pad 21 hard site launch facility (Launch Building 21/22) ($494,591.50).
1402S [05954] - septic tank for blockhouse ($1500.00).
1402T-1 [05952] - electrical substation (near pad 21) ($36,382.00).
1402T-2 [05953] - switching station near main gate ($6,574.00).
1402T-3 [05961] - electric substation near main gate ($4,428.00).
1402T-4 [05960] - switching station near pad 21 ($312.00).
1402JS [05962] - septic tank at the launch control building ($1,200.00).
01402B (1) and 01402B (5) - camera pads ($2,000.00).

In addition, there were many other lower order facilities including individual sewage lines, water mains, cable ducts, storm drains, parking areas, fences, electrical distribution lines, security lights, flood lights, and a fire alarm system. Shortly after completion of the final configuration, the pads were officially consolidated into Complex 21/22 with an inclusive cost to date of $1,199,603.50.[97]

The launch complex was vacated in 1964, and most of the equipment was removed over the subsequent years. A brief reprieve from obsolescence began on November 2, 1970, when the complex was assigned to the Army for use in the Dragon Program. According to a proposed plan dated January 19, 1971, the complex was chosen as the test firing site for the missile, with the weapons to be delivered on a daily basis from the ordnance area and kept for use in the ready storage facility (No. 1402E - Utility Room). Two

[95] Ibid.

[96] Ibid.

[97] Ibid.

launchers would be positioned in the firing area (on the paved surface in front of the Launch Building), and could be loaded simultaneously. The Launch Building was to be used for expended missiles in-process storage, and the Control Building was to serve as a shop. It is unclear if the project proceeded beyond the planning phase, as the complex was returned to the Air Force the following year upon discontinuation of the Army program.[98]

The complex was subsequently deactivated as a launch site. In later years, some of the buildings have been utilized for other purposes. Facility No. 5951 (Blockhouse) served as a storage building for Delta program equipment. In late 2005, the building became a storage facility/armory for the U.S. Coast Guard. Facility No. 5959 (Control Building) was utilized by Computer Science Raytheon for storage, with the upper floor serving as a repository for bound paper records, and the lower floor for spare equipment. In 1998, roof repairs and interior and exterior painting were conducted. The building is currently empty.[99]

Current facilities at Complex 21/22 are:[100]

5914 (1958) - Utility room - CX 21/22
5912 (1960) - Launch building 21
5961 (1958) - Substation
5952 (1958) - Electrical distribution building
5955 (1958) - Electrical switch station
5951 (1958) - Storage building - blockhouse 21
5954 (1958) - Septic tank
5962 (1958) - Septic tank
5959 (1960) - Storage building
Revetment (1957)
Pad 22 (1957)

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[98] Pan American World Airways Inc., "Complex 22, Proposed Test Range, U.S. Army Dragon Program, Quantity Distance Site Plan," Engineering Drawing, Directorate of Civil Engineering, Cape Kennedy Air Force Station, January 21, 1971; 45th Space Wing, "Cultural Resources Management Plan: Cape Canaveral Air Force Station, Patrick Air Force Base, Malabar Tracking Annex, and Jonathan Dickinson Missile Tracking Annex, 2004-2009," Environmental Support Contract (ESC), Contract No. FO8650-98-D-0016, (Patrick Air Force Base, FL: 45th Space Wing, 2004), n.p.

[99] Thomas E. Penders, "Launch Complex 21/22 District, Cape Canaveral Air Force Station, Brevard County, Florida," (Patrick Air Force Base, FL: 45th Space Wing, 45 CES/CEVP, 2006), building forms.

[100] "45th Space Wing Cultural Resources Management Plan," n.p.

Missiles Launches from Complex 21/22

Two different missiles were test fired from Complex 21/22: the Bull Goose and the Mace. The Mace program followed after the set of twenty Bull Goose launches which began at Complex 22 on March 13, 1957. The Mace made forty-four flights from Complexes 21 and 22 between October 29, 1959 and July 17, 1963.[101]

Bull Goose

The first missile to be tested and flown from what is now Launch Complex 21/22 was the Bull Goose. Designed to be a decoy weapon, the delta-winged missile was produced for the U.S. Air Force by Fairchild Engine and Airplane Corporation. Although concept work on the XSM-73 (Bull Goose) began in 1952, the Air Force didn't have a formal contract in place until December 1955.[102]

Specifications called for an intercontinental range and a speed of Mach 0.85. The subsonic flight was powered by a Fairchild YJ83-R-3 turbojet after takeoff courtesy of a Thiokol solid propellant rocket booster. An internal guidance auto-pilot provided directional control.[103]

The missile's purpose was to provide support for the U.S. Air Force Strategic Air Command's missile and aircraft squadrons by confusing enemy air defenses, specifically by penetrating and saturating enemy radar immediately before a strategic missile strike.[104] The primary goal was to simulate the radar signatures of B-36, B-47, and B-52 strategic bombers.[105] While the 33'6" missile was configured to carry a 500 pound payload of jamming devices, chaff, and radar repeaters, these payloads were never actually flown due to the short life of the program.[106]

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[101] Barton and Levy, Architectural and Engineering Survey and Evaluation, 15.

[102] Roy McCullough, "Missiles at the Cape: Missile Systems on Display at the Air Force Space and Missile Museum, Cape Canaveral Air Force Station Florida," (Champaign, IL: ERDC-CERL, 2001), 38.

[103] Andreas Parsch, "Goose," Encyclopedia Astronautica, (http://www.astronautix.com/lvs/goose.htm).

[104] Mike Machat and Anthony Accurso, "Winged Missiles of the U.S. Air Force," Airpower, May 2004, 19.

[105] Parsch, "Goose," (http://www.astronautix.com/lvs/goose.htm).

[106] Ibid., Cliff Lethbridge, "Goose (Bull Goose) Fact Sheet," Spaceline, (http://spaceline.org/rocketsum/goose.html).

Testing at Cape Canaveral began in March 1957, shortly after the Launch Complex was completed (see Figures 15 and 16). A total of twenty flights were accomplished from the site, five of which were dummy missiles (see Table 2).[107] All but one of the launches were classified as successes. The missile was assembled and processed in Hangar O (facility No. 1366) before transport to the pad. The solid booster was installed at the pad (see Figure 15). It is also likely that the missile was fueled at the launch pad.[108]

Table 2. Bull Goose/Goose Missile Launches from Complex 21/22.

Launch Date	Launch Vehicle	Launch Complex
3/13/1957	Bull Goose dummy	LC 22
5/13/1957	Bull Goose dummy	LC 22
6/27/1957	Bull Goose No. 2	LC 22
8/20/1957	Bull Goose No. 3	LC 22
9/26/1957	Bull Goose No. 4	LC 22
10/27/1957	Bull Goose No. 5	LC 22
11/27/1957	Bull Goose No. 6	LC 22
1/31/1958	Bull Goose No. 7	LC 22
3/18/1958	Bull Goose No. 9	LC 22
4/18/1958	Bull Goose No. 10 (Failure)	LC 22
5/15/1958	Bull Goose No. 8	LC 22
7/24/1958	Bull Goose No. 12	LC 21
8/28/1958	Bull Goose No. 13	LC 22
9/12/1958	Bull Goose No. 11	LC 21
9/18/1958	Bull Goose dummy	LC 22
9/25/1958	Goose dummy	LC 21
9/30/1958	Goose No. 14	LC 22
11/14/1958	Goose No. 15	LC 22
11/28/1958	Goose No. 18	LC 22
12/5/1958	Goose dummy	LC 21

The Air Force had plans to deploy Bull Goose missiles in 10 squadrons after purchasing nearly 2,400 missiles.[109] The first squadron was scheduled to be operational in 1961. The 10 operational sites were to be located along the northern tier of the United States. By May 1958, designs had been created for

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[107] Mark Cleary, electronic correspondence with author, 26 February 2008; Barton & Levy, Architectural and Engineering Survey and Evaluation, 8-15; http://www.floridatoday.com/maps/launches/MaceLaunches.htm; John Hilliard, electronic correspondence with Susan Enscore, 14 May 2007.

[108] Hilliard, electronic correspondence with Susan Enscore, 28 November 2007.

[109] McCullough, "Missiles at the Cape," 38.

launching shelters and the first two sites, Duluth, Minnesota and Ethan Allen Air force Base, Vermont, had been selected. The plans called for each missile to be housed in its own cell, with eight such cells contained in each semicircular shelter. Each site would contain 24 shelters (192 missiles). The first six shelters were expected to be ready by February 1960.[110] The construction of a prototype shelter at the Air Force Missile Test Center, Patrick Air Force Base was under contract by May 1958 and results were expected by that September. No evidence has been found to suggest that the prototype shelters were actually constructed at Cape Canaveral, and the Goose launches between May and December 1958 continued to use the mobile launcher platform. In any case, the planned deployments never came about. Problems with the booster, turbojet, wing structure, and inability to simulate the B-52 on radar proved too much, and the program was cancelled in December 1958.[111]

Mace

The Mace missile grew out of the Matador program. The USAF Matador B61A and B61C were also known as the Martin Matador TM61A and TM61C, Matador I and the Martin Matador MGM-1. The Matador was the first surface to surface missile built by the United States.[112] With over 280 launches, the Matador was the most ubiquitous missile at the Cape during the 1950s.[113] Over time, development of the Matador resulted in changes significant enough to warrant a new missile designation. Retaining the Matador's swept wing design, turbojet propulsion, and solid propellant launch booster, the TM-76 (Mace) also retained the Matador's mission as a tactical missile used to destroy ground targets.

One of the problems with the Matador had to do with the guidance system, which was ground controlled and depended on line of sight, thereby severely limiting the missile's range. The Goodyear Aircraft Corporation had begun development of an internal guidance system based on radar matching of film terrain

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[110] Memorandum from Colonel B.R. Lawrence, Assistant Director of Research & Development, DCS/D, USAF to Assistant Secretary of the Air Force, Materiel, "Construction of SM-73 (Goose) Missile Sites," 19 May 1958, Record Group 340, Records of the Office of the Secretary of the Air Force, Security Classified General Correspondence, 1956-1965, Box 279, File: 735-58, National Archives and Records Administration, College Park, MD.

[111] Parsch, "Goose," (http://www.astronautix.com/lvs/goose.htm).

[112] Museum of Aviation, "Missiles and Drones, Aircraft Collection, Martin Matador MDM-13A." (http://www.museumofaviation.org/home).

[113] Mark Cleary. "The 45th Space Wing: Its Heritage, History & Honors, 1950-1995," (Patrick Air Force Base, FL: 45th Space Wing History Office, 1996), 21.

maps, known as the Automatic Terrain Recognition and Navigation (ATRAN) system. If the radar scans differed from the maps, course corrections were initiated. Four years into Goodyear's ATRAN flight testing, in 1952 the USAF decided to utilize ATRAN for the Matador B, and Martin production began in 1954. The resulting missile was rechristened the TM-76 and called the Mace. Other differences in this first version of the Mace (TM-76A) from the two previous Matador variants (TM-61A and TM-61C) included a greater length which provided more fuel storage resulting in an increased range, as well as room for a larger warhead.[114] Another external difference was in wing design. The Matador had removable wings for transport that were bolted on for flight, but the Mace sported new foldable wings which enhanced mobility and decreased launch preparation time.[115]

The Mace was 44.3 feet long, with a 22.9 foot wing span and a 54 inch diameter fuselage. An Allison J33-A-41 turbojet engine powered the missile in flight with 5,200 pounds of thrust after being launched with the assistance of a Thiokol 130,000 pound thrust booster. The Mace utilized the same mobile launch and ground support equipment as the Matador. Depending on altitude flown, the Mace had a range of 800 miles and was able to reach Mach .85. Each missile came with a price tag of $250,000, substantially more than the $60,000 for the Matador.

A second variant of the Mace appeared after improvements to the original missile. Known as the TM-76 Mace B, the primary advance was an AC Spark Plug "A-CHEIVER" improved inertial guidance system that was jam-proof. An increase of range up to 1,400 miles and an expansion of operating elevations from under 1,000 feet to more than 40,000 feet also marked the B variant.[116]

The new guidance system performed best when the exact coordinates of the launch site were known and programmed into the system. This process was greatly facilitated by the use of fixed, hard shelter launch points. This led to the design and construction of prototype hard site launch facilities.[117]

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[114] McCullough, "Missiles at the Cape," 60-61; Lethbridge "Mace Fact Sheet," Spaceline, (http://spaceline.org/rocketsum/mace.html).

[115] McCullough, "Missiles at the Cape," 61.

[116] Machat and Accurso, "Winged Missiles of the U.S. Air Force," 26.

[117] Parsch, "Mace," Encyclopedia Astronautica, (http://www.astronautix.com/lvs/mace/htm).

There were a total of 44 Mace launches from Launch Pads 21 and 22 between 1959 and 1963 (see Table 3).[118] The first seven were from the pad 22 soft site while construction was ongoing on the new pad 21 hard site launch structure (see Figure 17). Once the new facility was complete, all remaining launches (beginning with the one on July 11, 1960) were conducted from the pad 21 hard site (see Figures 18 and 19). The first two all military launches occurred in November and December 1960, and were conducted by the 6555th's Mace Operations Division which was tasked with training Tactical Air Command personnel. After the last Performance Demonstration launch on June 21, 1961, the 6555th Mace Operations Division was disestablished, and the Mace Weapons Branch created to support the following 16 Mace launches. These launches were conducted by TAC's 4504th Missile Training Wing and completed the Mace Category III Systems Operational Testing and Evaluation (SOTE) program. When the SOTE program ended in April 1962, the Mace Weapons Branch was dissolved, and the final eight Mace launches from Cape Canaveral Launch Complex 21/22 were conducted by the TAC.[119]

Mace assembly was conducted in Hangar C next to Cape Canaveral Lighthouse across Lighthouse Road from Complex 21/22. All checkouts of guidance, electrical, propellant, and motor run ups were performed in the hangar. The Mace was fueled at the pad. The booster rocket was in place first, being loaded by a crane into one of the hard site launch bays. The Mace was then lifted by crane onto the launch rails in the bay (see Figure 20) and the rocket was attached. Finally, the guidance section and warhead components were lifted by crane and installed in the missile. The entire configuration was rechecked in the bay before launch (see Figure 21).[120]

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[118] Mark Cleary, electronic correspondence with author, 26 February 2008; Barton & Levy, <u>Architectural and Engineering Survey and Evaluation</u>, 8-15; <u>http://www.floridatoday.com/maps/launches/MaceLaunches.htm</u>; Parsch, "Mace," <u>Encyclopedia Astronautica</u>, (http://www.astronautix.com/lvs/mace/htm). Where known, the individual launch tube used from the hard site #21 is noted. It is not known conclusively which launches were Mace A or B.

[119] Penders, "Launch Complex 21/22 District," 12.

[120] Hilliard, electronic correspondence, 28 November 2007.

Table 3. Mace Missile Launches from Complex 21/22.

Launch Date	Launch Vehicle	Launch Complex
10/29/1959	Mace 56-2884	LC 22
12/4/1959	Mace 56-2893	LC 22
2/11/1960	Mace 57-2445	LC 22
3/31/1960	Mace 57-2452	LC 22
4/27/1960	Mace 58-1408	LC 22
6/3/1960	Mace 58-1391	LC 22
6/24/1960	Mace 56-2898	LC 22
7/11/1960	Mace 58-1417	LC 21
9/21/1960	Mace 58-1226	LC 21
10/7/1960	Mace 58-1427	LC 21
10/21/1960	Mace 59-4976	LC 21
11/15/1960	Mace 59-4980	LC 21
12/16/1960	Mace 56-2889	LC 21
3/7/1961	Mace 59-4979	LC 21 (21-2)
3/16/1961	Mace 59-4977	LC 21 (21-1)
3/28/1961	Mace 59-4978 (Failure)	LC 21 (21-2)
4/28/1961	Mace 59-4874	LC 21 (21-2)
6/2/1961	Mace 59-4876	LC 21
6/16/1961	Mace 59-4879	LC 21
6/21/1961	Mace 59-4883	LC 21
7/18/1961	Mace 60-5397	LC 21
8/4/1961	Mace 60-5399	LC 21
9/1/1961	Mace 60-5398	LC 21
9/22/1961	Mace 60-5400	LC 21
11/14/1961	Mace 60-5396	LC 21
12/5/1961	Mace 59-4887	LC 21
1/12/1962	Mace 60-5405	LC 21
1/12/1962	Mace 60-5401	LC 21
1/24/1962	Mace 59-4885	LC 21
1/26/1962	Mace 59-2468	LC 21
2/1/1962	Mace 60-5403	LC 21
2/8/1962	Mace 60-5406	LC 21
2/15/1962	Mace 59-4886	LC 21
2/21/1962	Mace 59-4889	LC 21
3/1/1962	Mace 58-1425	LC 21
3/2/1962	Mace 59-4888	LC 21
10/31/1962	Mace 58-1443	LC 21
11/8/1962	Mace 59-4891	LC 21
12/4/1962	Mace 59-4892	LC 21
12/11/1962	Mace 59-4890	LC 21
6/5/1963	Mace 58-1423	LC 21
6/12/1963	Mace 58-1435	LC 21
6/28/1963	Mace 59-2484	LC 21
7/17/1963	Mace 59-4981	LC 21

The Mace A underwent development and over 30 test launches at Holloman Air Force Base from 1958 to 1963.[121] A sheltered, atomic blast proof zero length launch site was constructed at Holloman and used to launch both Mace missiles and F-100 fighter aircraft, as the facility contained two bays (see Figure 22).[122] After the missile became operational, crew training occurred at the Holloman facility. The Mace B had a longer range, requiring testing over the ocean from Cape Canaveral for safety reasons.

The Mace went into full production in 1958 and were first deployed in West Germany in June 1959. The Mace B followed in 1961, becoming operational and being deployed in Okinawa that year. The Mace was stationed with units of the 38th Tactical Missile Wing, and provided the capability to reach Soviet Bloc nations with both conventional and nuclear warheads. Both Mace variants were withdrawn from service by 1969, after having established the record for longest operational service of any Air Force tactical winged missile.[123]

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[121] Parsch, "Mace," Encyclopedia Astronautica, (http://www.astronautix.com/lvs/mace/htm).

[122] George Mindling and Robert Bolton. US Air Force Tactical Missiles. (http://www.mace-b.com/38TMW/Missiles/History.htm).

[123] Lethbridge "Mace Fact Sheet;" Machat and Accurso, "Winged Missiles of the U.S. Air Force," 26.

ARCHITECTURAL DESCRIPTION OF LAUNCH COMPLEX 21/22

Pad 22 Architectural Description

Site Description

Pad No. 22 is situated at the corner of Lighthouse Road and Camera Road 'B'. According to drawings dated April 1956, the Pad 22 plot originally measured 340'0" x 500'0". Site preparations included land clearing and removal of a target pole probably used for range equipment calibration. Drainage swales were formed to move water off the site at the southeast site boundary. The initial paving plan was a slightly reduced version of the current configuration. A double bituminous surface treatment paved the area from Lighthouse Road to the revetment wall and the road leading to the concrete launch pad. A benchmark for the site's camera station was positioned just off the northeast edge of the site at the Camera Road 'B' pull-off.[124]

Primary and secondary power distribution entered the site near the revetment wall. Two new poles were erected, one in the existing line along Lighthouse Road and one adjacent to the revetment. From the two new poles ran a new perpendicular power line that tapped into the main industrial circuit.[125] Transformers for the new power service were mounted to the pole near the revetment.[126] A transformer vault was located at the east corner of the launch pad near Camera Road 'B'. All panels, conduit, and structures on the site were grounded using copper wire.[127]

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[124] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Grading Plan," Drawing No. CAN-0228 (Air Force Missile Test Center, Patrick Air Force Base, Florida and Pan American World Airways Inc., Guided Missile Range Division, 1956). Air Force Missile Test Center and Pan American World Airways Inc. hereinafter are referred to as AFMTC/PanAm; "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Paving Plan and Details," Drawing No. CAN-0229 (AFMTC/PanAm, 1956).

[125] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Primary and Secondary Power Distribution, Electrical Plot Plan," Drawing No. CAN-0231 (AFMTC/PanAm, 1956).

[126] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Critical and Industrial Power Transformer & Line Poles No. 1 & No. 2, Detail A & B," Drawing No. CAN-0232 (AFMTC/PanAm, 1956).

[127] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Primary and Secondary Power Distribution, Electrical Plot Plan," Drawing No. CAN-0231 (AFMTC/PanAm, 1956).

Revetment

A symmetrical V-shaped revetment wall protected the primary power and communications infrastructure for the site during launches. The revetment slope measures approximately 37′ deep; its street-side V-shaped alcove spans 25′ and is flanked by 15-foot splay walls. The revetment is fabricated of compacted earth fill covered in sand bags secured with netting. The sand bags are filled with a dry sand-cement mix made up of four parts washed sand to one part cement. Four-inch pipe weep holes are located 12-inch-on-center at the base and staggered at the same interval five feet higher on the revetment wall (see Figure 23).[128] Low scrub is now growing between the sand bags.

Four weatherproof utility panels (power, FAD, FAD-WRAMA communication, WRAMA communication)[129] were affixed to a metal mounting rack that was anchored into a dedicated concrete foundation on the street side of the revetment (see Figure 23).[130] Ducts from these panels ran underground in a straight line to the safety enclosure adjacent to the launch pad. An additional duct was constructed as a spare, although it was stubbed and capped since it was not intended for immediate use. A manhole was once located at a midpoint between the revetment and safety enclosure to allow for duct maintenance. The manhole lid measured 3′5″ in diameter and provided access to a four-foot-cube maintenance space enclosed with six-inch reinforced concrete walls.[131] This manhole is no longer visible and may have been filled when additional paving was laid during phase II construction.

Launch Pad

The early focal point of the site was a single 100-foot-square concrete launch pad. The pad slab was made up of six inches of concrete over 6″ of stabilized sub base. Its surface was

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[128] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Revetment Wall & Tie Down Anchor Details," Drawing No. CAN-0230 (AFMTC/PanAm, 1956).

[129] WRAMA (Warner-Robins Air Materiel Area) in Warner Robins, Georgia (now Robins AFB) was the agency responsible for communications-electronics equipment on the range during this period. FAD stood for Force Activity Designator.

[130] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Power Panel Layout in Revetment Area, Detail C," Drawing No. CAN-0233 (AFMTC/PanAm, 1956).

[131] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Primary & Secondary Power Distribution, Electrical Plot Plan," Drawing No. CAN-0231 (AFMTC/PanAm, 1956).

subdivided by construction, expansion, and dummy joints. (The dummy joints were simply scores in the concrete.) All of these joints were filled with hot poured jet fuel resistant sealant.[132]

Centered on the concrete pad were four missile tie-down anchors positioned to form a 14′0″ x 32′0″ rectangle. Each anchor was made up of a steel 40-degree V-shape embedded in a concrete footing located immediately below the concrete slab and its sub base. The large footings measured 5′0″ wide, 8′0″ long, and 3′6″ deep each. All tie-down anchors were positioned with their attachment points (located at the apex of the V) flush with the top of the concrete slab; hemispherical concrete slab cutouts provided access to them.[133] Centered on the southernmost end of the original four tie-downs is a steel plate with a T-shaped opening, possibly used as an alignment point for a transporter/ launcher. Additional tie-downs were added to accommodate the Mace launches beginning in late October 1959.

Launch Pad Safety Enclosure

The pad safety enclosure, painted in a yellow and white herringbone pattern, is located on the southwest edge of the concrete launch pad. It is made up of a seven-foot reinforced concrete wall flanked by equally high 45-degree splay walls. These walls are L-shaped in section (including the footing) and form the eastern-most boundaries of the enclosure. The western-most limits are open slab measuring 19′7″ x 26′7″. The slab is 6″ thick and rests on 6″ of stabilized subgrade. The line at which the walls met the slab was originally sealed with hot poured jet fuel resistant sealant.[134]

Three weatherproof power panels (power, FAD, and FAD-WRAMA communication) were located on a metal mounting rack affixed directly to the backside of the safety enclosure (away from the launch pad). Ducts ran from beneath each panel to the underground duct line leading to the revetment panels.[135] At some later date, a square opening was cut into the northernmost splay wall to

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[132] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Paving Plan and Details," Drawing No. CAN-0229 (AFMTC/PanAm, 1956).

[133] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Revetment Wall & Tie Down Anchor Details," Drawing No. CAN-0230 (AFMTC/PanAm, 1956).

[134] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Paving Plan and Details," Drawing No. CAN-0229 (AFMTC/PanAm, 1956).

[135] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Power Panel Layout in Pad Safety Enclosure, Detail D," Drawing No. CAN-0234 (AFMTC/PanAm, 1956).

align with a new cable trench in Pad 22, possibly for cables from the transporter/launcher (see Figure 24).

Launch Pad Power Outlets and Lighting

Two pad power outlets were located on each end of the pad's southwest-northeast centerline. Each was protected by a small concrete barrier wall measuring 2'6" by 2'6" x 0'8". Attached to a steel plate mounted on the back side of the barrier wall were two circuit breakers, each with two power receptacles.[136] These most likely provided power for launch equipment including air conditioning, guidance and control, checkout, and fuel pumping.[137] Near the westernmost outlet are four stubbed conduits that were added to the site at a later date.

Illumination for nighttime operations at the pad was provided by four pole-type fixtures (designated A, B, C, and D) located at the four corners of the pad. The poles were wood and extended 6'6" below grade. Power to the fixtures was provided by means of two underground lines originating from the safety enclosure. Fixtures A and C each had a junction box that extended power to fixtures B and D respectively. Each pole featured three vertically and horizontally adjustable floodlights on a wood cross arm. Each light produced 1000 watts of illumination that was directed with a broad beam reflector with cover lens. The fixtures were grounded with ground rods that extended from 10 feet below grade to ground wires that extended 1'6" beyond the top of the poles.[138] Light pole C is missing from the site.

Complex 21 Architectural Description

Site Description

Complex No. 21 is situated on Lighthouse Road, adjacent to and encroaching on the existing Pad 22 site. According to drawings dated July 1957, the Pad 21 project extended the existing Pad 22 site by 380' to the southwest. Original Complex 21 construction included the following:

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[136] "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Pad Power Receptacles & Flood Lighting, Details E & F," Drawing No. CAN-0235 (AFMTC/PanAm, 1956).

[137] Hilliard, written correspondence, 17 May 2008.

[138] Ibid.; "Cape Canaveral Aux. A.F. Base, G/Missile Launch Facility, Pad No. 22, Primary and Secondary Power Distribution, Electrical Plot Plan," Drawing No. CAN-0231 (AFMTC/PanAm, 1956).

- launch pad
- underground utility room (Building 5914)
- two sentry boxes
- blockhouse (Building 5951)
- transformer vault (Building 5952)[139]
- switching pad (Facility No. 5953)[140]
- blockhouse septic tank and drain field (Facility No. 5964)
- parking lot across Lighthouse Road

North and east access roads to Pad 21 were extensions off the existing Pad 22 pavement. An additional west access road crossed the site diagonally and linked Pad 21 to its blockhouse.[141] This same paving configuration exists today with minor variation.

Launch Pad

Similar to Pad 22, the focal point of the original Complex 21 was a 160’0” x 165’0” concrete launch pad, Pad 21. The pad was marked by a grid of construction, expansion, contraction, and weakened plane joints. An 8’0” gently sloped, thickened ‘shoulder’ reinforced the edge of the pad. A unique feature of the original Pad 21 was an unpaved rectangular opening on the street-side half of the pad. This opening was referred to as the ‘pit’. The pit was adjacent to the utility room utility tunnel and measured 61’0” wide x 110’0” long. Defined by three-foot-deep retaining walls, the pit was graded to be flush with the surrounding concrete pad slab.[142] From 1959 to 1960, Pad 21 was significantly changed when the launch building, Building 5912, was constructed on top of it.

Launch Pad Power Receptacle Posts and Lighting

Power receptacle posts are located on each end of the Pad 21 southwest-northeast centerline. Each post is made up of a 2’6” x 2’6” x 0’8” concrete barrier, steel mounting plate, two circuit

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[139] This building is not eligible for the National Register of Historic Places.

[140] This facility is not eligible for the National Register of Historic Places.

[141] “Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Key Plan and Site Plan,” Drawing No. 01-01402-002 (AFMTC, 1957); “Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Grading, Paving & Drainage,” Drawing No. 01-01402-003 (AFMTC, 1957).

[142] “Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Launching Pad Layout & Sections,” Drawing No. 01-01402-004 (AFMTC, 1957)

breakers, and two weatherproof power receptacles. All power apparatus is mounted on the post away from the launch pad, and would likely have been used for mobile launch equipment similar to that for Pad 22.[143]

The illumination setup for nighttime operations at Pad 21 was almost identical to that at Pad 22. Lighting was supplied by four pole-type fixtures located at the four corners of the pad. Power to the fixtures was provided by means of two underground lines originating from the underground utility room. The poles were wood, extended 6'6" below grade, and each featured three vertically and horizontally adjustable floodlights on a wood cross arm. Each lamp produced 1000 watts of illumination that was directed with a broad beam reflector with cover lens. Grounding for the fixtures ran from 10' below grade to 18" beyond the pole tops.[144] All four pole fixtures have been removed from the site.

Launch Pad Camera Pads

Five camera pads with numerical designations are located at the four corners of Pad 21 (Nos. 1, 2, 3, and 4) and at the center manhole in the utility tunnel that bisects the launch pad (No. 5). The typical camera pad is made up of a 1'0" x 4'0" concrete base that extends two feet below grade. Two 4-inch-square steel reinforced concrete posts protrude from the base; these are mounts for the Air Force Missile Test Center-supplied power and communications terminal boxes. The terminal boxes are mounted to face away from the pad. Below the power terminals at camera pads No. 1 and No. 3 are junction boxes to allow continuing service to camera pads No. 2 and No. 4 respectively (see Figure 25). Camera Pad No. 5 was similar, but its terminal boxes were mounted directly onto the inside wall of the center manhole rather than onto the concrete posts.[145]

Utility Room (Building 5914)

The utility room, Building 5914, is located between Pads 21 and 22. Radiating from it are the utility tunnel to Pad 21 and the communication trench to the blockhouse. Most of the 17'0" x 50'0"

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[143] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Utility Room—Plan & Elevations, Electrical," Drawing No. 01-01402-025 (AFMTC, 1957).

[144] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Duct Sections—Details & Wiring Diagrams, Electrical," Drawing No. 01-01402-026 (AFMTC, 1957).

[145] Ibid.; "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Site Plan, Electrical," Drawing No. 01-01402-020 (AFMTC, 1957).

rectangular shelter is under ground; approximately 3'0" of the structure is exposed above grade (see Figure 26). Walls, floor, and ceiling are made up of 12" thick reinforced concrete. The heavily-reinforced steel entry door is down a stairwell on the southeast side. Like the main structure, the floor, stairs, and walls of the stairwell are of reinforced concrete. Aluminum pipe rails, handrails, and topside rails protect against falling hazards. Topside access is through a 5'3" x 6'2" roof hatch with a metal counterweight cover. Other topside features include two 30" diameter openings for centrifugal roof exhausters. These fans have been removed and their openings are now sealed with square galvanized metal caps.[146] A small concrete projection on the northeast side of the utility room is a tunnel constructed to connect Pad 22 power panels with those of Pad 21. In the turf near the west corner of the utility room, remnants of the early carbon dioxide (CO_2) fire suppression system post and fire alarm pedestal can be found.[147]

The utility room interior housed the site's electrical distribution panels for lighting, camera pads, power receptacles, fans, sump pumps, and the CO_2 system. Interior architectural features included sloped openings to the utility tunnel and communication trench, overhead cable trays, and floor trenches with cover plates for utility conduit (see Figure 27). A duplex sump pump was located under the entry stairs and the reserve battery and CO_2 system tanks were located just inside the door.[148]

Utility Tunnel

A buried utility tunnel bisected Complex 21, running from the utility room, through the launch pad, and terminating just past the southwest side of the launch pad at its air intake (see Figure 28). The tunnel originally formed the southeast edge of the 'pit'. It measured 5'4" wide, had an interior clear span of four feet, and its depth varied. CO_2 lines ran the length of the trench. Three manholes were situated along the tunnel to provide

[146] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Utility Room—Plans, Sections & Details," Drawing No. 01-01402-013 (AFMTC, 1957); "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse & Utility Room—Plans, Riser Diagrams & Details," Drawing No. 01-01402-018 (AFMTC, 1957).

[147] A second fire alarm pedestal is located adjacent to the communication trench near the blockhouse.

[148] Ibid.; "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse & Utility Room—Plans, Riser Diagrams & Details," Drawing No. 01-01402-018 (AFMTC, 1957).

service access.[149] Twenty-four-inch diameter heavy traffic covers were centered over each manhole. At the manholes, the interior clear span increased to seven feet. The utility tunnel turned upward at the far-end air intake, an above-ground terminus to the tunnel. The air intake featured screened louvered openings on two sides and a single access hatch on a third side. Rungs were embedded into the interior surface of the wall just inside the access hatch to allow personnel to step down into the tunnel.[150]

Blockhouse (Building 5951)

A one-story blockhouse, Building 5951, was built for Complex 21 directly on Lighthouse Road west of the launch pad. The main building plan is almost a perfect square, measuring 65’8” x 66’4”. A small 10’4” x 20’0” ell is located on the west corner. The exterior features 12” thick reinforced concrete walls with chamfered corners and a virtually flat reinforced concrete roof slab with no parapets. The structure was designed according to criteria set forth in Engineer Manual 1110-345-405, *Fundamentals of Protective Design (Non-Nuclear)*, dated 1946.[151] The building exterior lacks significant architectural embellishment except as noted below. Additional exterior details include metal gutters and downspouts, an aluminum roof access ladder, original roof-mounted flood lights, newer wall-mounted lighting fixtures, roof-mounted lightning rods, and recent security fencing immediately around the facility. Concrete stoops are located outside the doors at the main entry, air conditioning room, and new emergency egress. The main entry stoop is sheltered by a reinforced concrete cantilevered awning with drip edge.

Users enter the blockhouse on the northwest façade through a centrally located vestibule that originally featured two sets of double doors. The outermost pair of blast resistant doors has been removed. The vestibule opens to a double-loaded corridor that provides access to the toilet, utility, communications, and work rooms. The corridor ends at the fire and control room that occupies the southeast end of the building.

The *fire and control room* is currently used as office space, but a couple of original features remain from its fire and control

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[149] “Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Instrumentation—Site, Sections, Details & Schedules,” Drawing No. 01-01402-012 (AFMTC, 1957).

[150] Ibid.

[151] “Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse—Plans, Sections, Details & Schedules,” Drawing No. 01-01402-011 (AFMTC, 1957).

functions: two observation ports and extensive floor trenching. The southeast mid-façade observation port is angled at 45 degrees for launch viewing. The east near-corner observation port is positioned at 30 degrees to account for its closer vantage point. Both ports feature bullet-proof glass, new interior steel-grid grates, and dedicated exterior overhead gutters.[152] Floor trenches (with removable covers) are located around the perimeter of the space, with two additional mid-space trenches bisecting the floor plane into thirds. Newer low-pile carpet covers the remainder of the floor. Original ductwork remains exposed just below a dropped ceiling. The siren, floodlights, and CO_2 system controls were originally located on the wall next to the 45-degree observation port. On the opposite side of the same port was once an aerovane recording instrument that took wind speed and direction readings from its rooftop transmitter.[153] (The readings were used for trajectory and guidance calculations.) All of this equipment has since been removed.

According to some 1958-59 floor plans, the fire and control room was later subdivided into the *launch control room* and the *flight control room*. The launch control room featured a pad safety officer (PSO) console under the 30-degree observation port.[154] The flight control room was outfitted with a data transmission system (DTS) receiver and power supply, X/Y recorders, and an operations control console.[155] All of this instrumentation equipment has since been removed. A recent addition to the fire and control room is a flush hollow metal egress door that was added to the southeast façade some time after May 2005.

Just outside the fire and control room was the *communications room*. Access to the space was originally through a small sliding door; this door has since been replaced with a hinge-type door. The removable wood partitions that once sectioned off the space from the adjacent work room have been removed, but the

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[152] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse—Port, Toilet, Ladder & Misc. Details," Drawing No. 01-01402-010 (AFMTC, 1957).

[153] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse Lighting—Plan, Elevation & Details," Drawing No. 01-01402-027 (AFMTC, 1957).

[154] "Cape Canaveral Missile Test Annex, Blockhouse 21-22—Installation of Cable Ladder and Power to Mod II Sequencer, Site Plan and Floor Plan," Drawing No. CAN-3074 (AFMTC/PanAm, 1958); the pad safety officer has decision-making authority relating to all safety issues that arise during processing and launching activities.

[155] "Cape Canaveral Missile Test Annex, Blockhouse 21—Flight Control and Sequencer Rooms, Power for Instrumentation, Partial Floor Plan," Drawing No. CAN-4034 (AFMTC/PanAm, 1959).

communications pit in the floor remains. This pit is two feet deep and occupies a floor area measuring 4'10" x 9'10". Ten removable steel checkered plates cover the pit and provide access (see Figure 29). The original function of the communications room was to house the WRAMA rack.[156]

With the removal of its wood partitions, the communications room became part of the *work room*. The work room, originally L-shaped, is now a rectangular space. It features the work room pit, located in the floor of the former ell, and adjacent to the communication trench on the building exterior (see Figure 29). This pit is approximately 5' deep and transitions interior WRAMA conduit to the exterior trench. Twenty removable steel checkered plates cover the pit and provide access. In addition to the pit, the telephone terminal cabinet for the site was originally located on the northeast wall of the work room.[157] Original ductwork remains exposed just below a dropped ceiling.

Across the hall from the work room and adjacent to the fire and control room is the *utility room*. The utility room now functions as a weapons vault. Access to the space was originally through a 6'2"-wide sliding door. This door has since been replaced with a smaller hinged door and the excess opening has been sealed. (The new door is steel-plated for compliance with weapons vault regulations.) The utility room housed the blockhouse electrical distribution panels for interior and exterior lighting, power receptacles, siren and CO_2 controls, spare breakers, HVAC components, and the former sentry boxes. Floor trenches with removable covers run along the southwest and southeast walls, the latter running across the central corridor and into the communications pit. According to a 1958 partial floor plan, the utility room was later redesignated the *sequencer room* because it housed the launch sequencer equipment racks.[158]

The sequencer was a rather complex set of relays that controlled vehicle- and range-associated functions. The latter primarily involved initiating camera starts. As a device that triggered

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[156] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse—Plan, Elevations, Details & Schedules," Drawing No. 01-01402-008 (AFMTC, 1957).

[157] Ibid.; "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse Power & Under Floor Plans, Elevations, & Details," Drawing No. 01-01402-028 (AFMTC, 1957).

[158] "Cape Canaveral Missile Test Annex, Blockhouse 21—Flight Control and Sequencer Rooms, Power for Instrumentation, Partial Floor Plan," Drawing No. CAN-4034 (AFMTC/PanAm, 1959).

events in a timed fashion, the sequencer was driven by the Central Timing system, an ultra-accurate digital clock.[159]

Adjacent to the utility room near the front entrance is the *toilet room.* This space originally featured two toilet stalls, two lavatories, and two urinals. The same number and type fixtures are present today. The sight barrier screens that originally obscured views of the toilet stalls and urinals have been removed, and the stall partitions have been replaced. A drinking fountain that was once located outside the toilet room in the corridor has been removed.[160]

Two additional blockhouse spaces are accessible only from the building exterior: the air conditioning room and the former compressor housing. The *air conditioning room* occupies the northeast corner of the main building mass. A single 4′0″ blast resistant door on the northwest façade provides access. Contemporary air conditioning equipment replaces the two original refrigeration units.[161] Ductwork runs through the inside walls to condition interior space (see Figure 30).[162] The utilitarian pendant light fixtures remain from the original design. Openings in the wall adjacent to the compressor housing allow for air intake and exhaust.

The *compressor housing* no long contains compressors; it now functions as a hazardous materials store room. It protrudes from the main building mass at a lower height and is of different construction. The space is supported by a reinforced concrete frame and enclosed with concrete masonry unit infill walls. Access is through a set of double doors on the northwest side. Venting is provided by fixed metal louver openings on the southwest and southeast elevations.[163] The interior is generally

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[159] John P. Anderson, electronic correspondence with Susan Enscore, 22 February 2008.

[160] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse—Plan, Elevations, Details & Schedules," Drawing No. 01-01402-008 (AFMTC, 1957); "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse—Port, Toilet, Ladder & Misc. Details," Drawing No. 01-01402-010 (AFMTC, 1957).

[161] The current air conditioning equipment requires only one condenser; this condenser is located outside and adjacent to the former compressor housing. The original two refrigeration units required four condensers that were located similarly.

[162] Over time these walls have been patched to accommodate various HVAC upgrades.

[163] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Blockhouse—Plan, Elevations, Details & Schedules," Drawing No. 01-01402-008 (AFMTC, 1957).

devoid of finishes; however the original utilitarian ceiling-mounted light fixtures remain (see Figure 30). The two 8-inch-high concrete isolation pads that had once supported compressors No. 1 and No. 2 have been removed.

Typical room finishes throughout the blockhouse included asphalt tile floors, rubber baseboards, painted concrete or concrete block walls, and acoustical tile ceilings. One exception was the toilet room with ceramic tile floors, baseboards and wainscoting, and plaster walls and ceiling. The other exceptions were the utilitarian spaces with concrete floors, no baseboards, and exposed concrete walls and ceilings.[164]

Communication Trench

A communication trench that allowed for monitoring launch status from the blockhouse runs between the blockhouse and underground utility room. The trench is protected overhead by six-inch-thick precast concrete covers. These covers vary in size by location. Where the communication trench crosses the Pad 21 access road, more substantial 10-inch thick traffic covers provide overhead protection. Both types of covers feature lift rings for their removal. The trench interior is divided into two 4-foot-clear channels whose depth varies by location. Ten-inch-thick reinforced concrete walls are typical. To carry the communication lines, the trench walls were lined with adjustable cable brackets.[165]

Site Security

When the original Complex 21 was constructed, a security fence was erected that secured both Complex 21 and Pad 22 as a single site. The galvanized chain link fence was supported by three-inch-diameter posts anchored into four-foot-deep concrete footings, reinforced with diagonal bracing as needed, and topped with point barbed wire to deter unauthorized entry. Security lighting was mounted at intervals on specified fence posts. Two points of entry existed: one at the Pad 22 access road near the revetment, and one at the Complex 21 blockhouse. Vehicular access was controlled at each location by a rolling chain link gate operated by security personnel.[166] The chain link fence was

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[164] Ibid.

[165] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Instrumentation—Site, Sections, Details & Schedules," Drawing No. 01-01402-012 (AFMTC, 1957).

[166] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Fencing Details," Drawing No. 01-01402-006 (AFMTC, 1957).

relocated from Complex 21/Pad 22 to NASA in 1966 for their use elsewhere.[167]

Security personnel were housed in sentry boxes located adjacent to the site's two vehicular access points. Each sentry box was of wood frame construction, was clad in aluminum clapboard siding, and featured a flat roof with a built-up gravel finish. In plan, outside measurements were 6'7-$^{1}/_{4}$" square. The floor-to-ceiling height was 8'½". Personnel could observe site conditions and persons approaching the access points through aluminum double-hung windows located on three sides of the structure. The fourth side featured a hollow aluminum entry door. With the exception of electrical service for power and lighting, the sentry boxes had no other utilities.[168] The blockhouse and revetment sentry boxes were removed in 1963 and on November 25, 1974 respectively.[169]

Complex 21/22 Architectural Description

Site Description

Phase III additions to Complex 21 and the subsequently consolidated Complex 21/22 facilities occupied the plot within the boundaries previously established by Pad 22 and Complex 21. Phase III construction added the following facilities to the complex:

- launch building (Building 5912)
- support building (Building 5959)
- transformer vault (Building 5961) and transfer switch [170]

At some time between Phase II and III construction, two structures (a Wonder Building and a small square concrete building) had been erected over the pit area of Pad 21. To make way for construction of the launch building, both structures were removed from the site. The Wonder Building was sheared off at the anchor bolts and relocated off Road 'D' near the carpenter, auto repair, and Auto Inspection Equipment (A.I.E.) shops. The portions of its floor slab and foundation that coincided with the launch building footprint were removed, while the remaining slab

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[167] Real Property Accountable Record for Complex 21/22, Cape Canaveral Air Force Station, Florida.

[168] "Cape Canaveral Aux. A.F. Base, Missile Launching Facilities, Complex 21, Sentry Box, Architectural," Drawing No. 01-01402-007 (AFMTC, 1957).

[169] Ibid.

[170] These facilities are not eligible for the National Register of Historic Places.

and foundation work was left in place. Likewise, the square concrete building situated between the Wonder Building and Lighthouse Road was removed.[171]

Utility conduit and lines in the Pad 21 utility tunnel and in excavation areas were relocated as necessary to accommodate new construction. Storm culverts between Pad 21 and Lighthouse Road were partially regraded to divert water runoff around the new buildings; new electrical and signal (i.e. telephone) manholes, catch basins, and headwalls were also provided as necessary.[172] A 22-foot-wide circular access drive was added to the existing road at the southwest corner of the site.[173] Lastly, following erection of the launch building, two 12′0″ conical earthen embankments were added against its east and south corners. The embankments counterbalance the outward forces from the fill that supports the underside of the ramped interior launch bays. These embankments feature six-inch-square concrete curbs with galvanized pipe weep holes.[174]

Control House (Building 5959) [175]

The control house is located immediately adjacent to the west corner of the launch building and it shares a concrete stair landing with the launch building. Even though this facility is secondary to the launch building, it was constructed prior to it. The control house is rectangular in plan, measuring 20′0″ x 48′0″ (two 10-foot bays by three 16-foot bays). The exterior features a two-story reinforced concrete frame enclosed by concrete block infill panels. Floor and roof surfaces are of concrete slab construction. Like the nearby blockhouse, the built-up roof is

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[171] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Site Plan—Existing Facilities," Drawing No. AW 60-08-164, Sheet 3 (Reynolds, Smith & Hills, 1959); "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Site Plan—Wonder Building," Drawing No. AW 60-08-164, Sheet 36 (Reynolds, Smith & Hills, 1959); remnants of the Wonder Building slab remain visible west of the launch building; these include filled trenches, metal plates, and equipment pad locations.

[172] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Site Plan—Existing Facilities," Drawing No. AW 60-08-164, Sheet 3 (Reynolds, Smith & Hills, 1959).

[173] "Cape Canaveral Missile Test Annex, Access Road, Complex 21, Site Plan," Drawing No. AS 11-12-05, Sheet 1 (U.S. Army Corps of Engineer District—Jacksonville, 1958).

[174] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Elevations—Launch Facilities," Drawing No. AW 60-08-164, Sheet 4 (Reynolds, Smith & Hills, 1959).

[175] This facility has also been referred to as the control building, support building, and storage building.

virtually flat with no parapets.[176] The exterior aesthetic is a straightforward expression of the building's structural systems. Other exterior details include:

- metal gravel stops at the rooflines
- newer metal gutters and downspouts
- a replacement metal roof ladder
- three vent openings (original louvered vent, circular replacement vent, and substitute window air conditioning unit)
- replacement metal one-light and flush doors
- metal exterior stairs with pipe railing (front and side)
- exterior circulation platforms (front and back) made up of metal grating and pipe railing (some rail sections removable)

The second floor functioned as the *launch control center* for the launch building and housed power panels and consoles for missile launch operations. Equipment included *industrial circuit* consoles for power control and distribution, radiation detection, launch command and status control, the pad safety officer, launch safety monitoring, and guidance testing. A second industrial control panel powered control house lighting, air conditioning, exhaust fans, and strip heaters. A *critical circuit* control panel powered emergency lighting, beacon and target lights, warning and public address systems, television monitors and cameras, sequential cameras, the telemetry vans, the CO_2 system, and launch building roll-up door positions.[177]

A removable 'false' plywood floor, tiled with aluminum edging and outfitted with various cutouts, is raised one foot above the second floor slab on adjustable jacks. The raised floor once accommodated the myriad of cables that ran from wall-mounted system terminal boxes to their corresponding launch building conduits (see Figure 31).[178] Four rows of fluorescent lighting fixtures hang from the ceiling eight feet above the raised floor.

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[176] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Floor Plans & Elevations, Control Building, Architectural," Drawing No. AW 60-08-164, Sheet 8 (Reynolds, Smith & Hills, 1959).

[177] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Single Line Diagram Electrical System, Electrical," Drawing No. AW 60-08-164, Sheet 24 (Reynolds, Smith & Hills, 1959).

[178] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Wall Sections & Door Details, Control Building & Launch Bays, Architectural," Drawing No. AW 60-08-164, Sheet 9 (Reynolds, Smith & Hills, 1959); to protect control house occupants, these conduits were equipped with explosion-proof seal-off provisions ["Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Framing Plans and Details, Launch Control Center, Structural," Drawing No. AW 60-08-164, Sheet 20 (Reynolds, Smith & Hills, 1959)].

These fixtures are supplemented by round ceiling-mounted fluorescent fixtures.

At some time after initial construction, the northwest third of the second floor was sectioned off with wood framed partitions to create a new observation area possibly for VIPs and other visitors away from the Launch Control Center.[179] The northeast partition had a vented one-light access door that remains. The southwest partition had windows for viewing the remainder of the second floor from within the newly created space. Portions of this partition have been removed (see Figure 31). Inside the new room, a ledge runs the length of the remaining windowed partition. Toilet room access is through this new space.

A small *toilet room* is located in the north corner of the second floor. It features the original wall-mounted sink, toilet stall, and circular vent opening; newer toilet and urinal fixtures replace the originals. In January 1961, a drinking fountain was relocated to the second floor of the control house from a hangar elsewhere on base.[180] It was placed outside the toilet room against the preexisting plumbing wall.[181] While the drinking fountain has been removed, its service pipes remain. The toilet sanitary line exits the control house and angles away from the building, past the nearby transformer vault, and to the septic tank and drain field marked by the six-inch-square reinforced concrete posts (see Figure 32).[182]

The first floor of the control house was largely utility space that housed a generator and the power distribution panels for the control house and the launch building. A small hazard area (possibly because of a fuel line termination point) with shelving on two walls is located in a corner room accessible only from the building exterior. The most notable feature of the first floor is the network of floor trenches and pits. All of the trenches are covered with checkered plates with lift holes. A large conduit pit is located behind the hazard area and under some shelving units. It too is covered with checkered plates, two of which have openings for wall-mounted cable trays. A smaller pit is located a

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[179] Hilliard, written correspondence, 17 May 2008.

[180] Real Property Accountable Record for Complex 21/22, Cape Canaveral Air Force Station, Florida.

[181] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Plumbing and Air Conditioning, Mechanical," Drawing No. AW 60-08-164, Sheet 21 (Reynolds, Smith & Hills, 1959).

[182] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Sanitary Sewage Details, Civil," Drawing No. AW 60-08-164, Sheet 22 (Reynolds, Smith & Hills, 1959).

short distance away at the intersection of multiple floor trenches. This pit, once open, is now covered.[183] The space is illuminated by a series of rectangular and circular ceiling-mounted fluorescent light fixtures.

Seven concrete equipment pads were once located among the trenches and pits, but have since been removed along with their equipment. The pad nearest the hazard area was positioned perpendicular to the other pads to provide room for a fuel line pipe. A similar pipe was located in the hazard area (see Figure 33).[184] Both pipes were connected to the underground fuel line trench to the launch building.[185]

The original control house heating and cooling systems were quite simple. The first floor ventilation system consisted of no more than air intake through a louvered vent door and air exhaust through a ventilation fan on a remote wall. The door has since been replaced with a solid one-light door and the fan opening now houses a window air conditioning unit. Second-floor climate control was provided by a self-contained air conditioning unit (with air-cooled rooftop condenser) and strip heaters. The cooling unit remains in place, but its rooftop condenser has been removed (see Figure 34).[186]

Launch Building (Building 5912)

The last addition to the site under Phase III construction was the launch building. This facility is the current focal point of Complex 21/22. It has an irregular plan that features two virtually identical ramped launch bays (designated No. 1 and No. 2) for launching Mace missiles. The launch building was sited so the centerline of launch bay 2 coincided with the centerline of Pad 21 beneath it.[187] The two-story reinforced concrete structure measures 63′2-$^{1}/_{8}$″ x 68′0″ (without track platforms and exhaust

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[183] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Floor Plans & Elevations, Control Building, Architectural," Drawing No. AW 60-08-164, Sheet 8 (Reynolds, Smith & Hills, 1959).

[184] Ibid.

[185] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Miscellaneous Details, Launch Bays, Structural," Drawing No. AW 60-08-164, Sheet 17 (Reynolds, Smith & Hills, 1959).

[186] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Plumbing and Air Conditioning, Mechanical," Drawing No. AW 60-08-164, Sheet 21 (Reynolds, Smith & Hills, 1959)].

[187] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Site Plan—New Facilities," Drawing No. AW 60-08-164, Sheet 2 (Reynolds, Smith & Hills, 1959).

ducts). Each launch bay measures 24′6″ wide and varies in height across its 63′0″ length. The two bays are separated by a 5′ interstitial space enclosed in 6″ thick precast concrete walls. Oversized columns are embedded in the interstitial space at approximately 12′0″ intervals. These structural supports tie into areas of doweled reinforcement at the 18″ thick exterior walls.[188] The sweeping shed roof that covers the launch building mimics the slope of the ramped launch bays inside.

Extending from the front of each launch bay is a 52′3″-long concrete missile track platform elevated 18′6-$^{7}/_{8}$″ from grade. Each platform is supported by six chamfered 16″ square reinforced concrete columns and features a missile loading track. A concrete pad is located at mid-track and steel grating spans the track rails elsewhere. Utility panels and lighting fixtures are mounted on platform railings. While no longer present, a winch was likely mounted at the remote end of each platform to aid missile loading. Between the two elevated track platforms is a 28-riser concrete stairway with pipe railing that provides exterior access. Where the platforms meet the launch bays are two oversized metal roll-up doors with aluminized steel over-head door hoods and side door guides.[189] Between these doors is a maintenance ladder.[190]

Two large steel *exhaust ducts* are located on the back (street side) of the building. They taper from 10′10″ in diameter at the building interior to 8′0″ in diameter at the building exterior. The northernmost duct is straight and measures 20′0″ in length. To keep launch debris on site, the southernmost duct (55′0″ in length) is bent 90 degrees. The inside radius at the bend is 12′0″ and the outside radius is 20′0″. Reinforced concrete

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[188] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Foundation Plan—Launch Bays, Structural," Drawing No. AW 60-08-164, Sheet 11 (Reynolds, Smith & Hills, 1959); "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Floor Framing Plan—Launch Bays, Structural," Drawing No. AW 60-08-164, Sheet 12 (Reynolds, Smith & Hills, 1959).

[189] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Wall Sections & Door Details, Control Building & Launch Bays, Architectural," Drawing No. AW 60-08-164, Sheet 9 (Reynolds, Smith & Hills, 1959); "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Sections—Launch Bays, Structural," Drawing No. AW 60-08-164, Sheet 14 (Reynolds, Smith & Hills, 1959).

[190] A series of roof-mounted outdoor floodlights positioned at 45-, 60-, and 75-degree angles once flanked each of the overhead doors. Similarly mounted test and warning lights were positioned at the launch bay centerlines above the overhead doors. All of these lights have since been removed ["Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Lighting, Catwalks and Warning System, Electrical," Drawing No. AW 60-08-164, Sheet 28 (Reynolds, Smith & Hills, 1959)].

footings that support the ducts outside the building measure 1’3” x 10’0” and feature a curved cutout to accept the 8’0” diameter duct. The anchor block footing at the bend of the longer duct is a more substantial structure, measuring 13’0” x 14’0”.[191]

Above the exhaust ducts and between the launch bays is the *camera balcony*. Terminal boxes, junction boxes, and conduit for the sequential and TV cameras were mounted on its back wall (see Figure 35). A larger splice box near the floor carried conduit under the building and to the utility tunnel. Additional conduit for the TV cameras was routed through the balcony floor, to the cable tray under the catwalk, and to the control house TV monitors (see Figure 35).[192]

Users entered the launch building through one of four ¼” steel plate doors (two per launch bay) on the back (street-side) façade. The two outer doors are located on the 45-degree splay walls; the two center doors are located beneath the camera balcony. Launch bay lighting panels and the hazard warning system were once located below the camera balcony as well.[193] The nonfunctioning CO_2 discharge buttons for the latter are marked “hazardous alarm” (see Figure 36). The fire hose cabinet that was located in the same area was removed in 1966, though its plumbing connections remain adjacent to the center bay 2 door.[194]

Other exterior building features include:

- reinforced concrete pipe tunnel for CO_2 drop (see Figure 36) (CO_2 cylinder cabinets for both launch bays have been removed)

- first floor concrete platforms (one centered between launch bays and two others at corner 45-degree splay walls)

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[191] “Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Exhaust Duct Details, Structural,” Drawing No. AW 60-08-164, Sheet 18 (Reynolds, Smith & Hills, 1959).

[192] “Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Facilities for Cameras and Communication, Electrical,” Drawing No. AW 60-08-164, Sheet 30 (Reynolds, Smith & Hills, 1959).

[193] As part of phase II construction, an area warning system was developed down Lighthouse Road in the northeast direction. System development included construction of a small compressor house, air receiver tank, and warning horn mount [“Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Area Warning System, Electrical,” Drawing No. AW 60-08-164, Sheet 37 (Reynolds, Smith & Hills, 1959)].

[194] Real Property Accountable Record for Complex 21/22, Cape Canaveral Air Force Station, Florida.

- steel stairs and grated catwalks with pipe hand rails lighted with rail-mounted weatherproof 100-watt incandescent fixtures

- built-up roof with short parapets, four power roof ventilators, four roof scuttles, and a metal roof ladder

- exterior cable tray under catwalk leading to control house

Launch bay ceilings are pitched barrel vaults formed by a series of three-pin steel arches. Their radiuses to the inside face of the ceiling measure 15′9″. Spun glass insulation encased in perforated corrugated aluminum once lined the barrel vaults in both bays, but has since been removed. A series of 1′6″-wide grated service walkways flanked the launch bays in the 'attic' space enclosed between the barrel vaults and the shed roof. The walkways provided access to a series of recessed fixtures that perforate the barrel vaults. These fixtures include explosion proof light fixtures (circular), paired sequential camera positions (square), TV cameras (square), and observation ports (square) (see Figure 37). To support the cameras, 45-degree camera platforms ran the length of the attic on both sides of each launch bay.[195]

Launch bay floors are made up of stepping reinforced concrete work platforms positioned along side the ramped missile guide tracks to allow technicians to work on the various stages of the missiles while inside the bays. Additional removable metal work platforms (painted yellow) were provided to span the missiles once loaded. The concrete work platforms also provided mounting locations for various cameras, instrumentation, and lighting equipment (see Figure 38). Some of these mounts and equipment have been removed. Steel stairs connect the platforms and pipe railing is located at all floor height changes. Two manholes were

[195] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Insulation Details—Launch Bays, Architectural," Drawing No. AW 60-08-164, Sheet 7 (Reynolds, Smith & Hills, 1959); "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Sections and Elevations—Launch Bays, Structural," Drawing No. AW 60-08-164, Sheet 15 (Reynolds, Smith & Hills, 1959); "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Ceiling Chamfers, Insulation Details—Launch Bays, Architectural," Drawing No. AW 60-08-172, Sheet 1 (Reynolds, Smith & Hills, 1959); "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Ceiling Chamfers, Framing Plan & Details of Chamfers, Structural," Drawing No. AW 60-08-172, Sheet 2 (Reynolds, Smith & Hills, 1959); sequential camera No. 1 and No. 2 were both on the north and south walls of each bay; TV camera No. 1 and No. 2 were both on the north wall of each bay; TV camera No. 3 was on the south wall of each bay.

provided per launch bay along the CO_2 pipe tunnel for CO_2 system access.[196]

The 5’6”-wide missile guide tracks located below the work platforms directed the missiles out of their bays. They run the length of the bays and are made up of varying sections (some with guard rails and some without; some adjustable and some fixed). The tracks were illuminated by a series of recessed 200-watt incandescent light fixtures. Track access was by way of one of four ladders (rungs are painted red).[197]

Spanning the tracks are rectangular lift pits, two per launch bay. Aligned with the lift pits are two pairs of short, stout columns that support the upper and lower spring support assemblies. These assemblies supported the missiles prior to launch.[198] Near the bottom of the missile tracks are four pairs of tie-down fittings comprised of eyebolts embedded into the track walls at 45-degree angles. At the top of the tracks were rollers to move the missiles down the tracks. The roller device is present in bay 2, but missing from bay 1. The lift pits, spring support assemblies, tie-downs, and rollers facilitated missile loading (see Figure 39 and Figure 40).

During launch preparations, the missiles were supplied with electrical power, ground instrumentation connections, gases, and propellants through a number of umbilical hoses. The azimuth alignment unit for each launch bay was positioned at the topmost interior platform, in the east corner near the overhead door (see Figure 41). These units have since been removed. A floor trench with checkered cover plates was located on the same platform to direct cabling from the azimuth alignment unit to the missile track.[199] Also on the same platform was the missile operations communications system, known as MOPS. This was the range-wide amplified intercom system. Pairs of explosion proof MOPS cabinets were mounted to the walls of each bay 4’8” above the floor (see

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[196] “Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Insulation Outline and CO-2 System—Launch Bays, Architectural,” Drawing No. AW 60-08-164, Sheet 6 (Reynolds, Smith & Hills, 1959).

[197] “Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Floor Framing Plan—Launch Bays, Structural,” Drawing No. AW 60-08-164, Sheet 12 (Reynolds, Smith & Hills, 1959).

[198] “Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Miscellaneous Details—Launch Bays, Structural,” Drawing No. AW 60-08-164, Sheet 16 (Reynolds, Smith & Hills, 1959).

[199] “Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Floor Framing Plan—Launch Bays, Structural,” Drawing No. AW 60-08-164, Sheet 12 (Reynolds, Smith & Hills, 1959).

Figure 41). Conduits for the MOPS ran to the utility room tunnel, along the southwest side of the launch building, and into the end wall of the control house (see Figure 33).[200]

[200] "Cape Canaveral Missile Test Annex, G/M Launch Facility—Complex No. 21, Facilities for Cameras and Communications, Electrical," Drawing No. AW 60-08-164, Sheet 30 (Reynolds, Smith & Hills, 1959); John P. Anderson, electronic correspondence with Susan Enscore, 29 February 2008.

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HISTORIC DRAWINGS

The technical drawings used for research in this study are not available for inclusion in this document. Those drawings are stamped with the following distribution restriction:

> Drawings HAVE NOT been characterized as being released to the public domain. They MAY contain EXPORT CONTROLLED TECHNICAL DATA that is controlled for export under the Export Administration Regulations (EAR) or the International Traffic in Arms Regulations (ITAR). Reference NASA Procedural Requirements (NPR) 1600.1, Chapter 5.24 for Sensitive But Unclassified (SBU) Controlled Information.

Due to this stipulation, it is not possible to reproduce in this document the drawings used to gather information about the design, construction, and use of facilities at Launch Complex 21/22, CCAFS.

APPENDIX: FIGURES FROM DATA PAGES

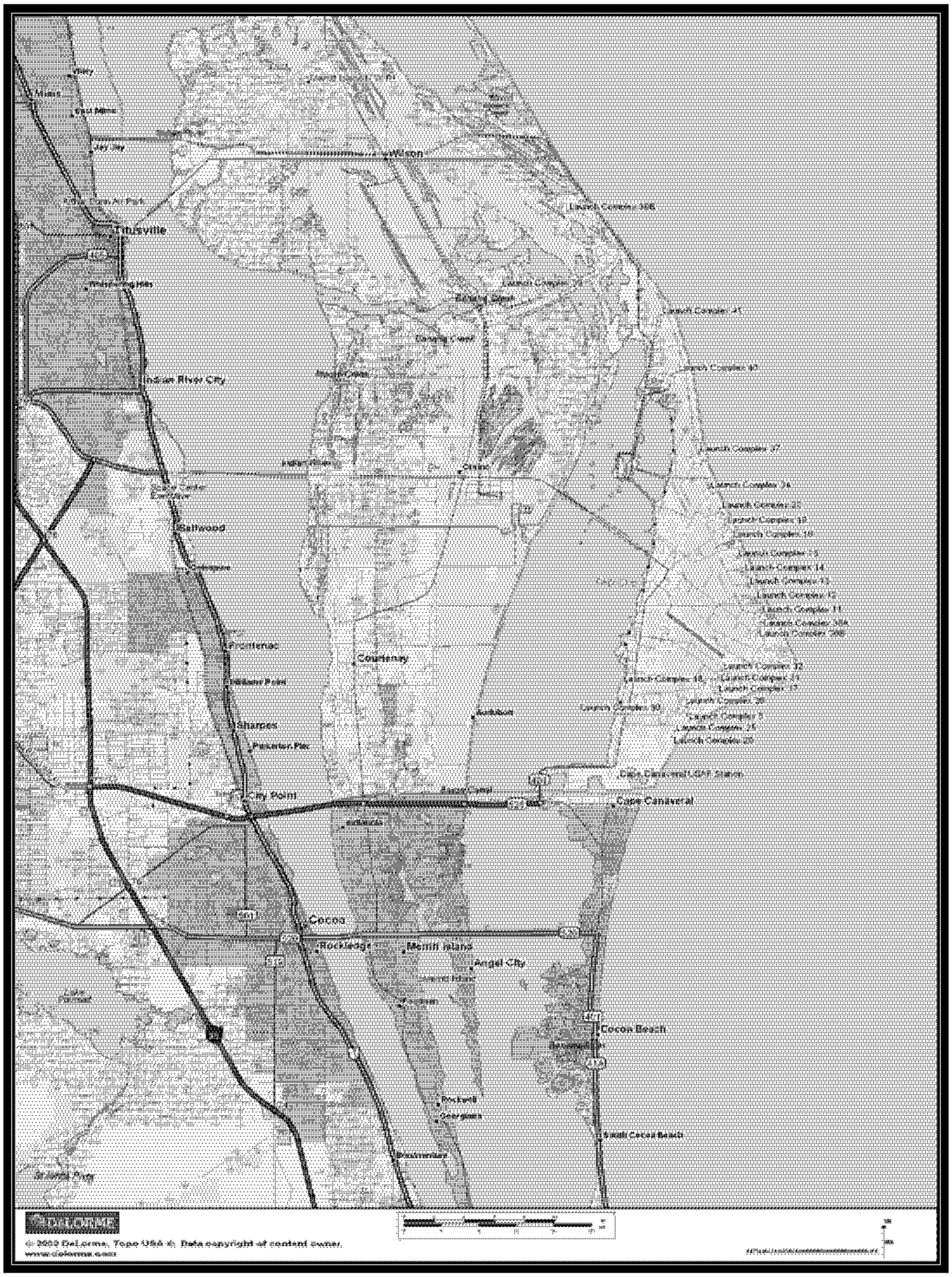

Figure 1. Location of Cape Canaveral Air Force Station, Brevard County, Florida (USAF, 2006).

Figure 2. Aerial of Cape Canaveral with use areas indicated, 1957 (National Archives and Records Administration [NARA]).

Figure 3. The Industrial Area at Cape Canaveral, 1962 (NARA).

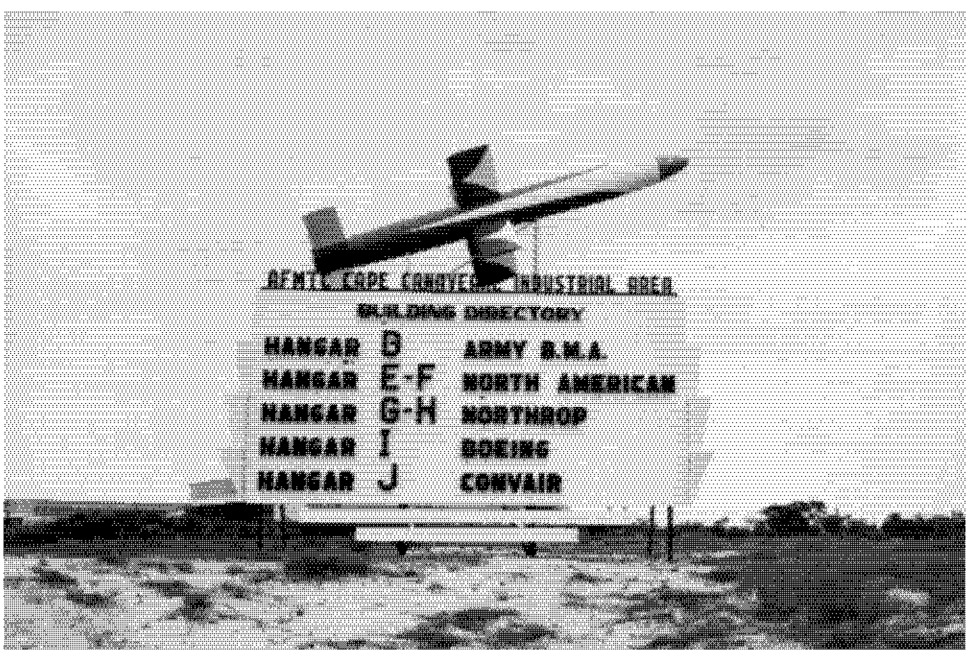

Figure 4. Hangar identification sign, 1957 (NARA).

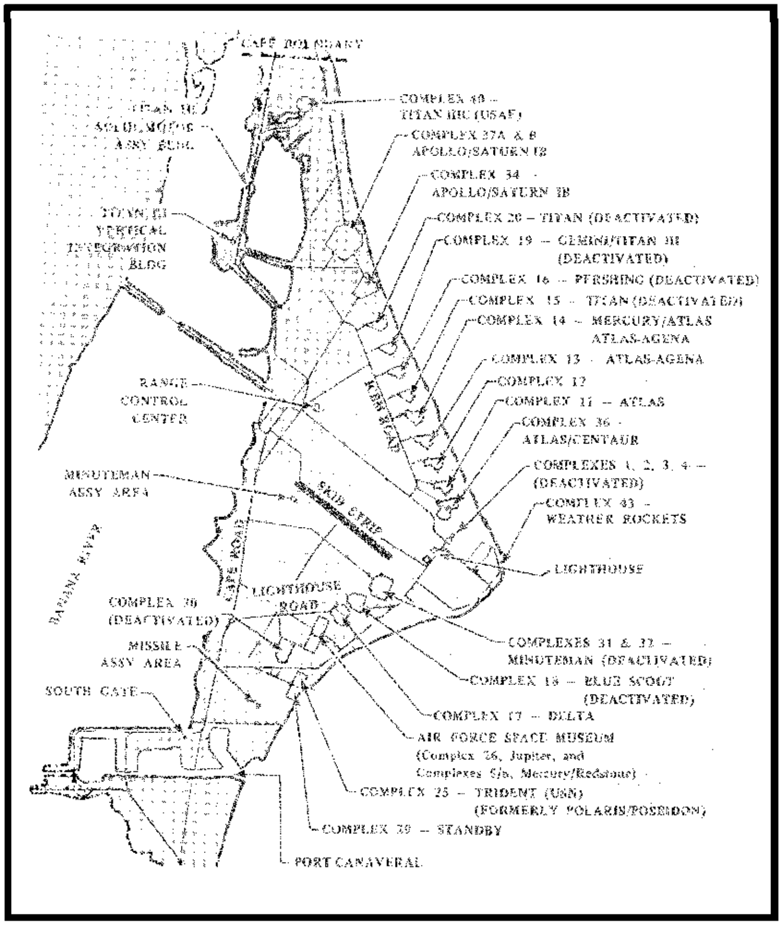

Figure 5. Map showing the many types of missile launches supported by CCAFS Complexes (USAF).

Figure 6. Locational context of Launch Complex 21/22 (USAF, 2006).

Figure 7. Contemporary oblique aerial photograph of Launch Complex 21/22 (USAF, 2006).

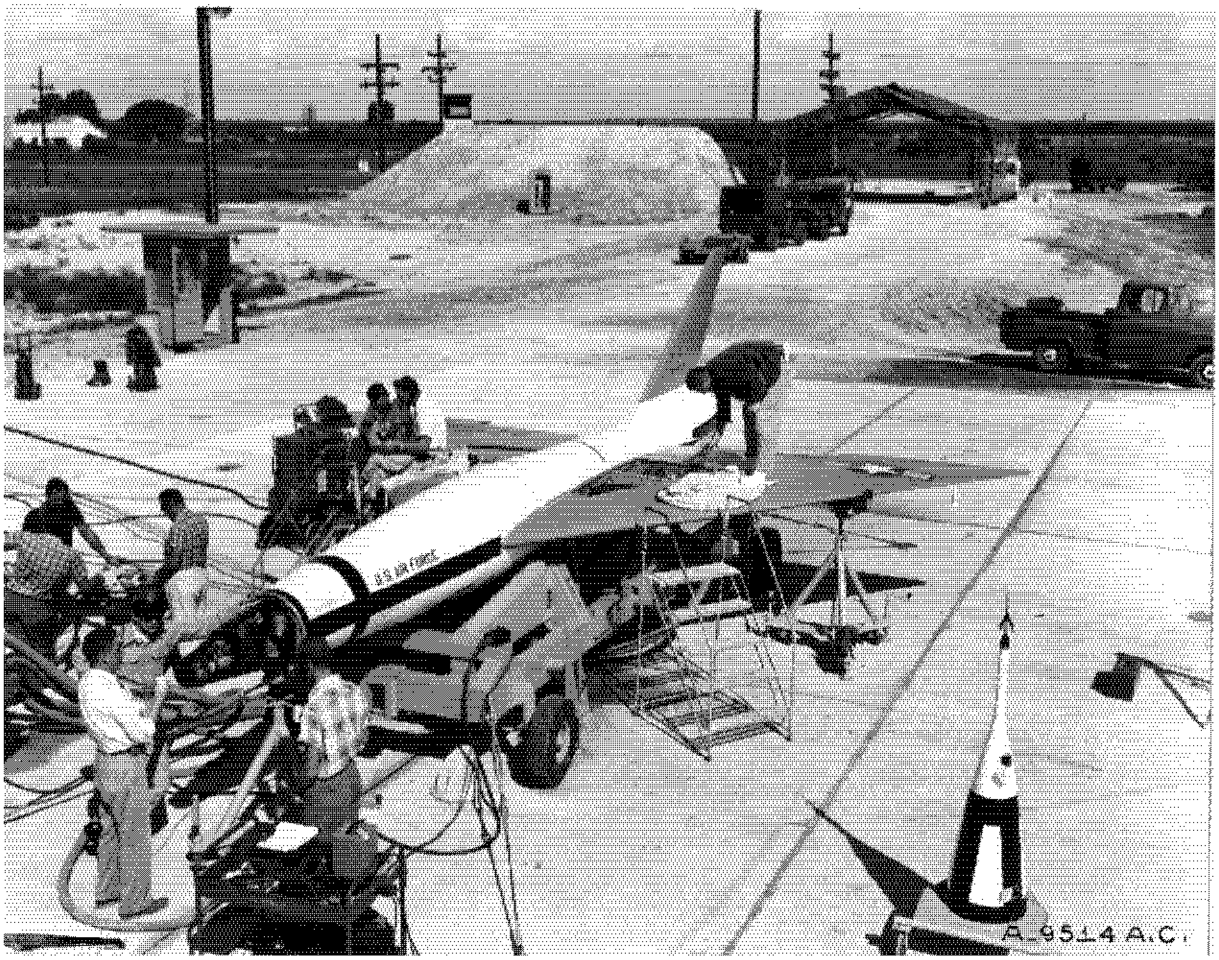

Figure 8. View of facilities at Launch Pad 22 for Bull Goose launch, 27 June 1957; revetment and mobile missile shelter visible to rear (NARA).

Figure 9. Facilities at Launch Pad 22 before a Bull Goose launch, 26 June 1957; control van and periscope tower visible behind revetment (NARA).

Figure 10. Fairchild technician inside control van parked behind revetment at Pad 22, 7 May 1957 (NARA).

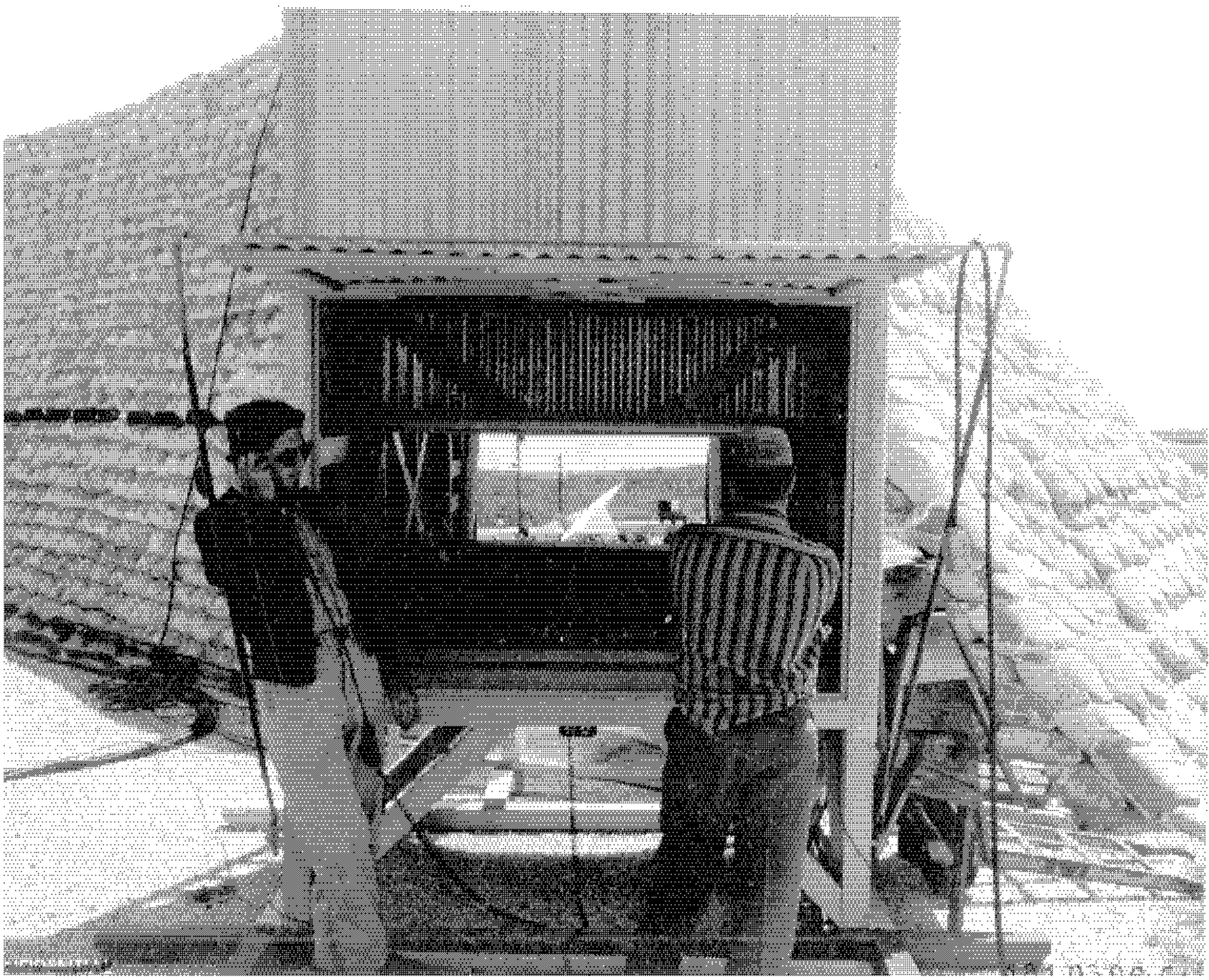

Figure 11. View of Bull Goose missile through periscope behind revetment at Pad 22, 19 April 1958 (NARA).

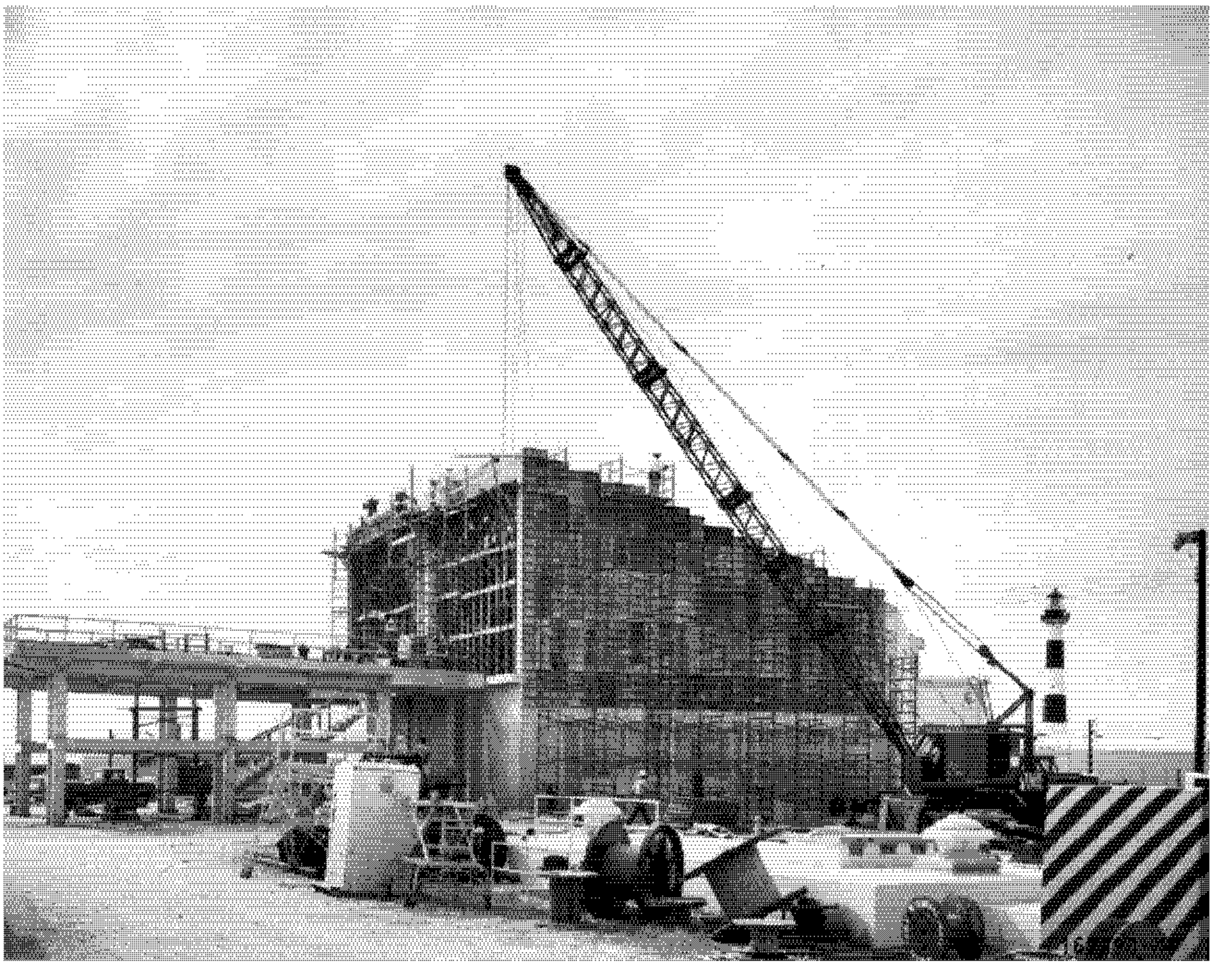

Figure 12. Construction of Mace hard site launch facility, 7 January 1960 (NARA).

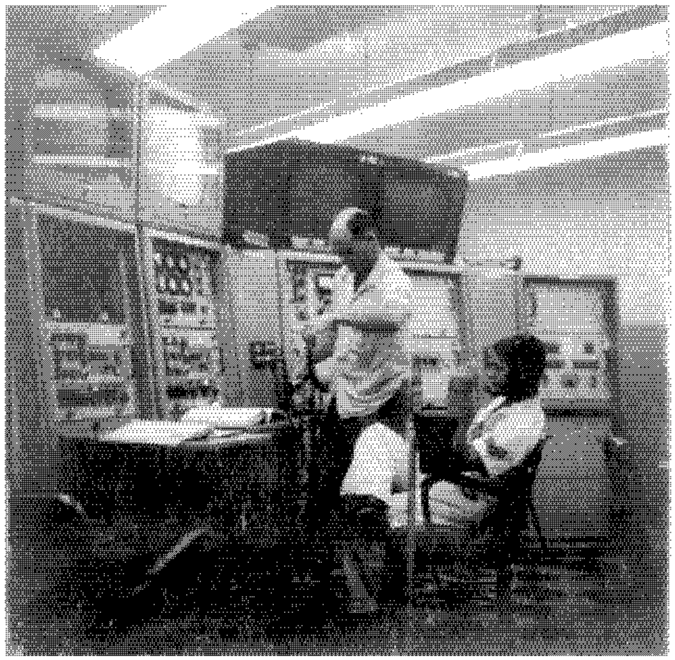

Figure 13. Technicians in the Control Building preparing for a Mace launch, 6 October 1960 (NARA).

Figure 14. Airmen in the Control Building before a Mace launch, 6 October 1960 (NARA).

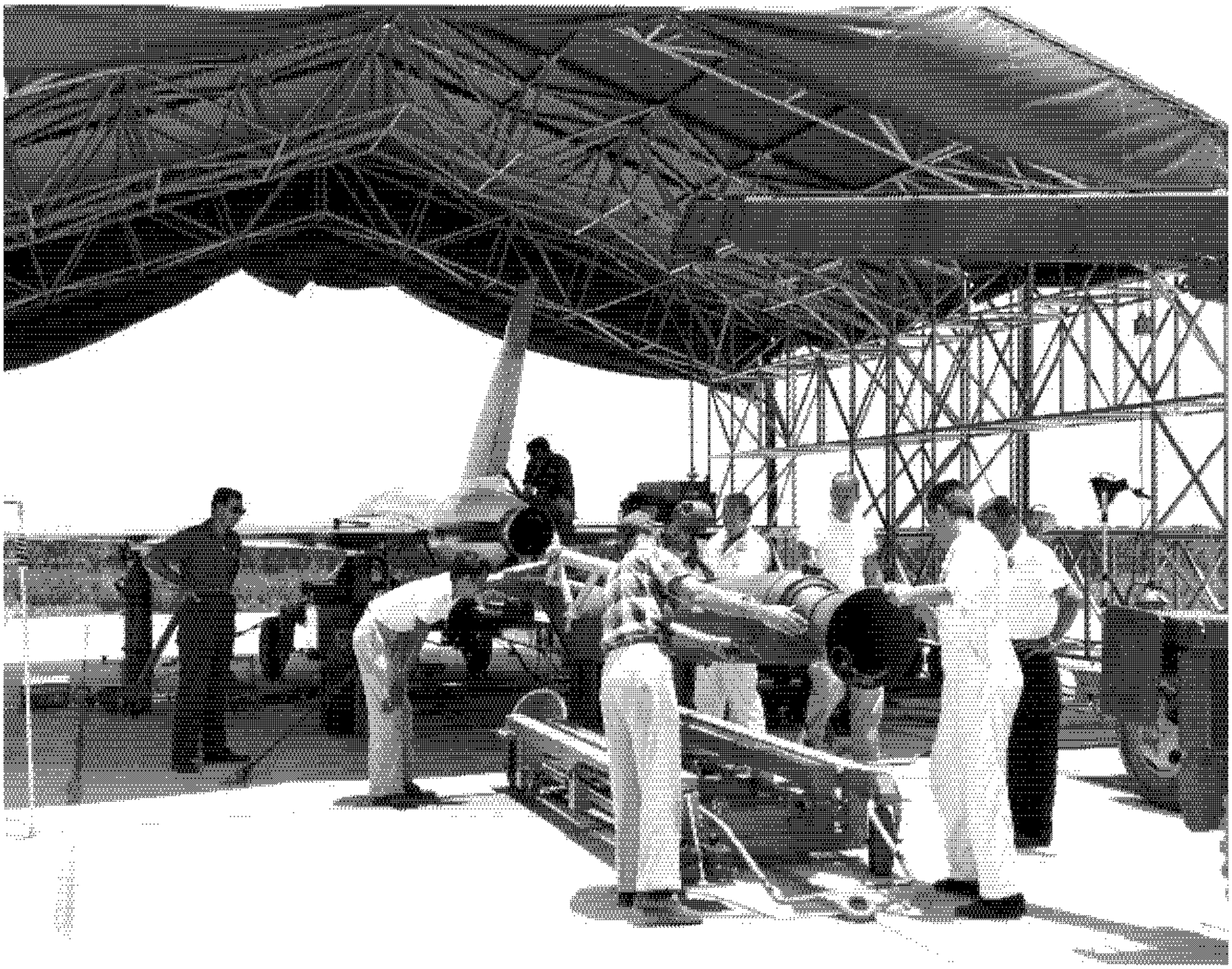

Figure 15. Technicians joining the booster to the Bull Goose missile on Pad 22, 26 June 1957 (NARA).

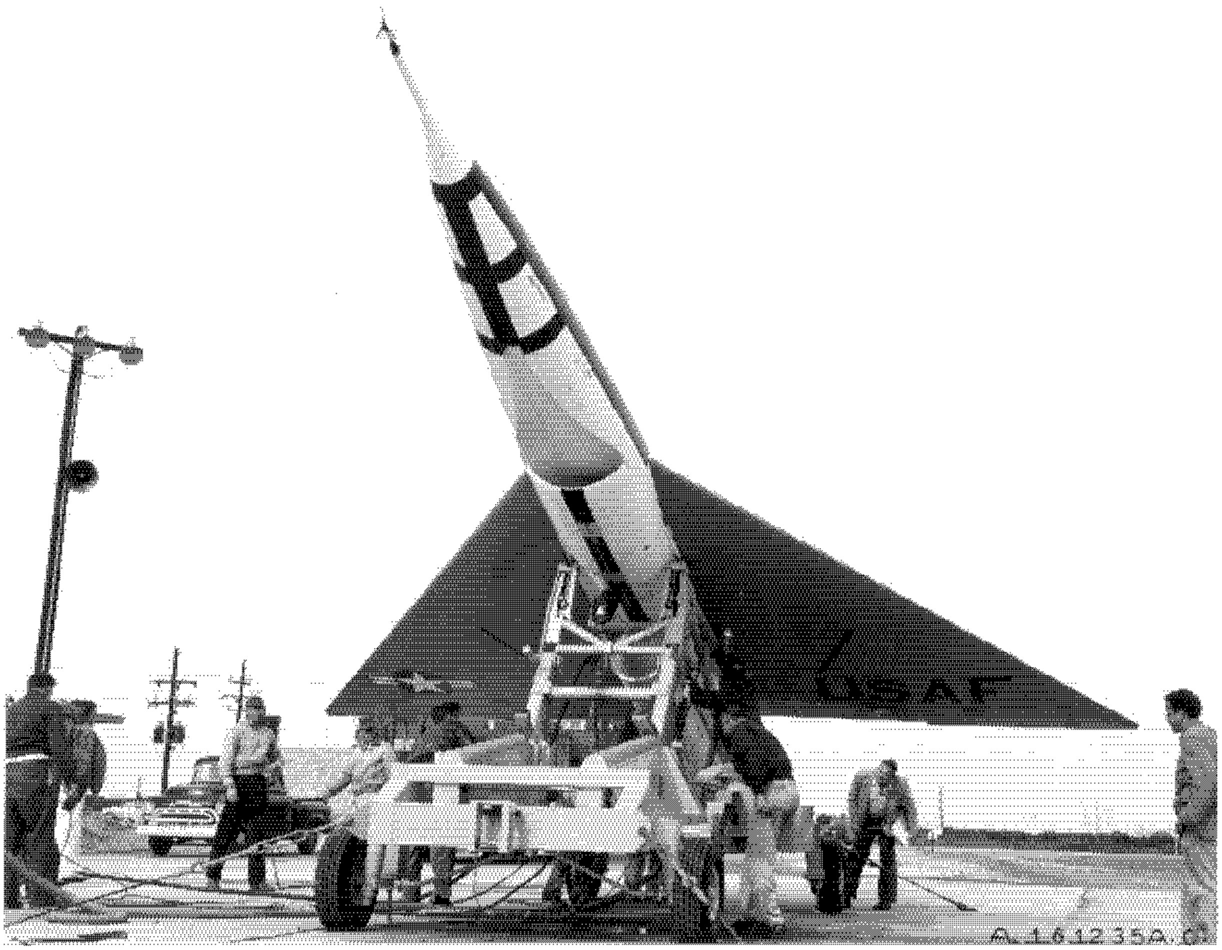

Figure 16. Last minute adjustments to the Bull Goose on its launcher at Pad 22, 22 January 1958 (NARA).

Figure 17. First Mace launch from Cape Canaveral, 29 October 1959, Pad 22 (NARA).

Figure 18. Mace launch from the Pad 21 hard site, 21 September 1960 (NARA).

Figure 19. One of the last Mace launches from Complex 21/22, 12 June 1963 (NARA).

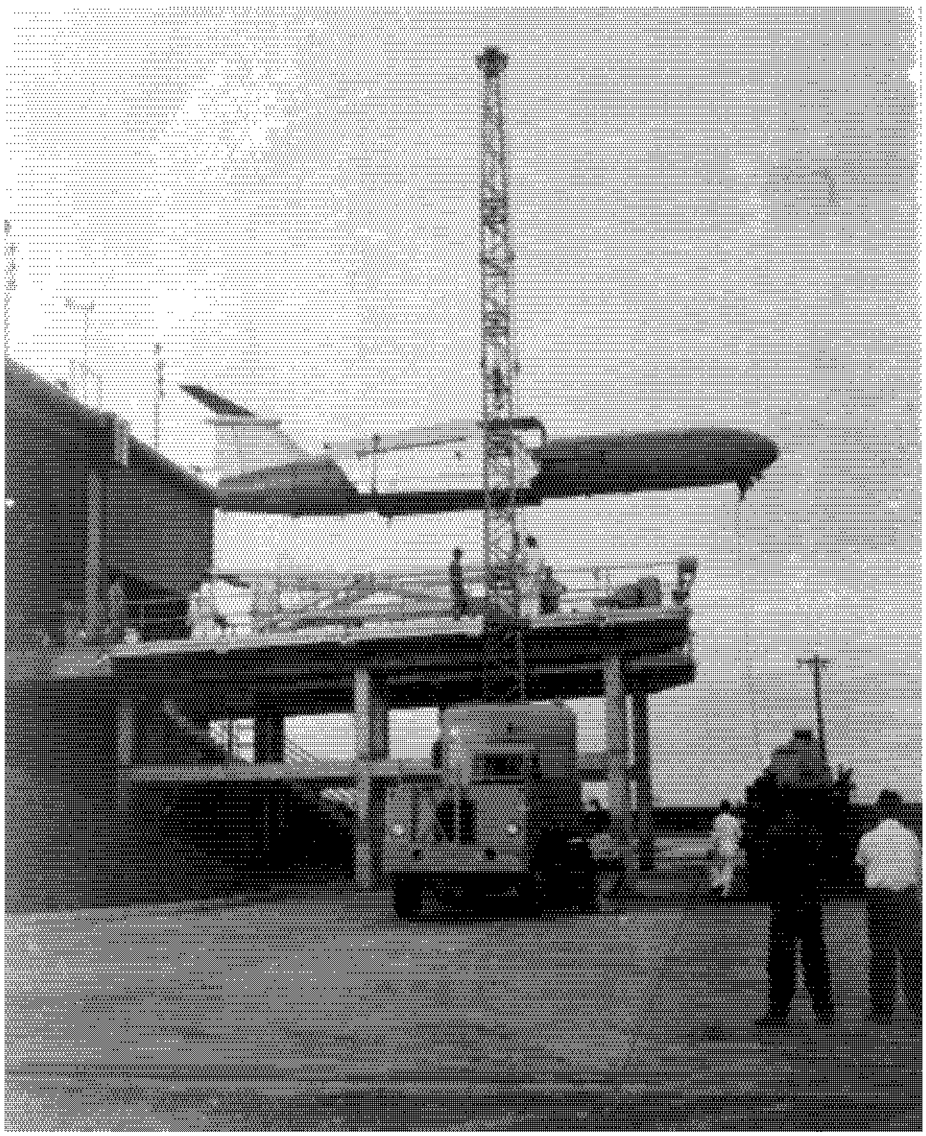

Figure 20. Mace missile is lifted by crane into the launch bay, Pad 21 (NARA).

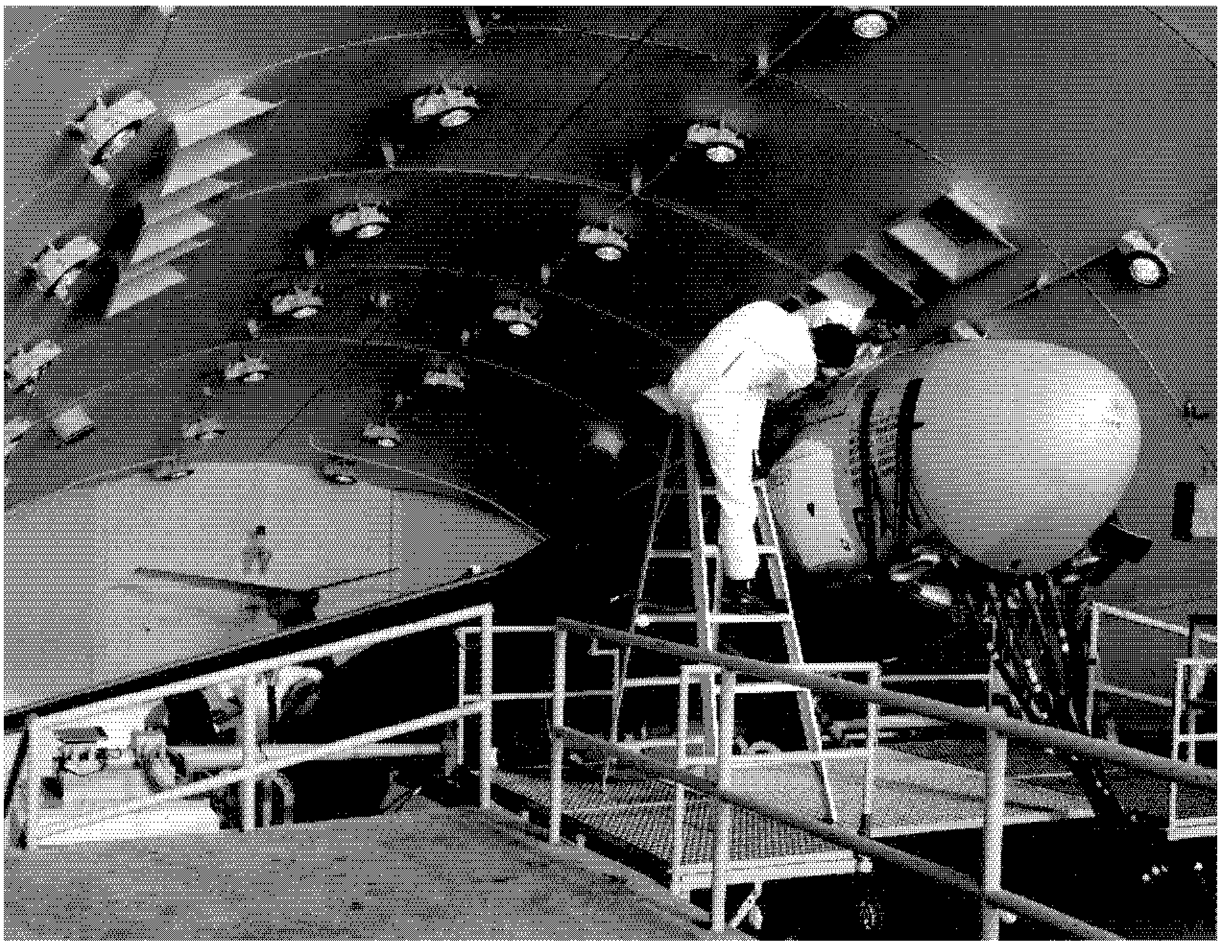

Figure 21. Final check-out before launch of a Mace missile, Pad 21, 31 October 1962 (NARA).

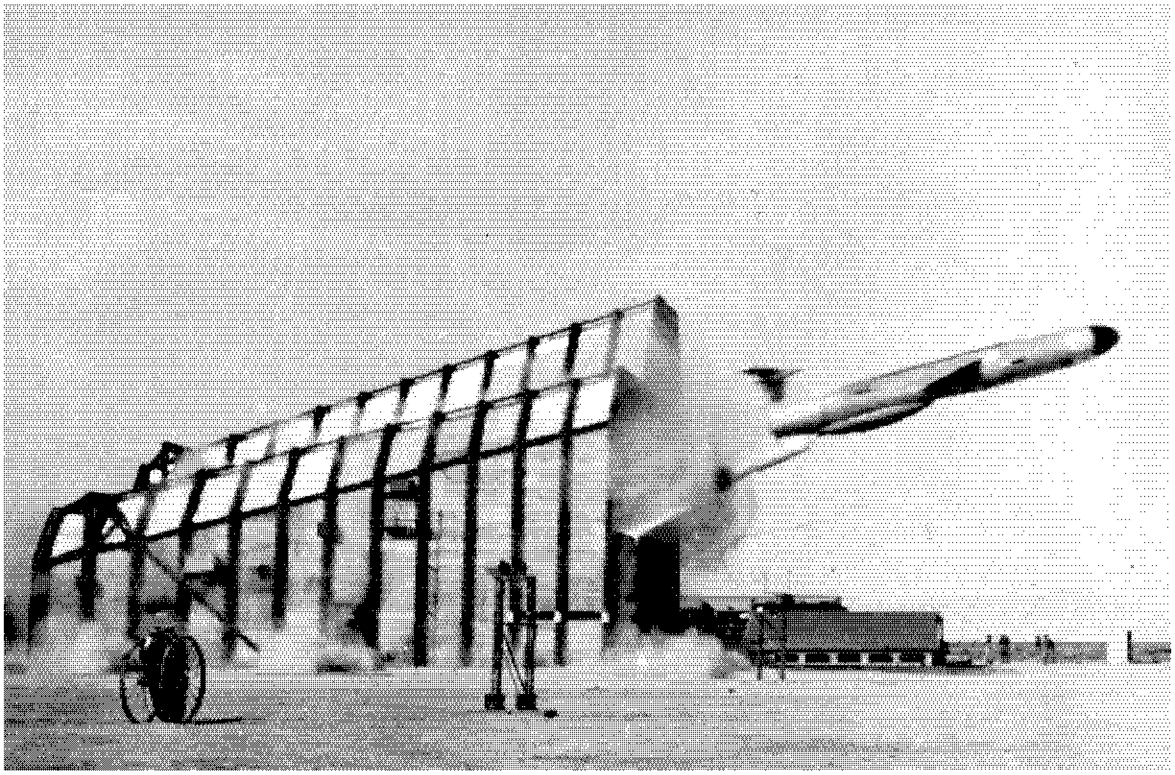

Figure 22. Mace missile being launched from the zero length launch facility, Holloman AFB (NARA).

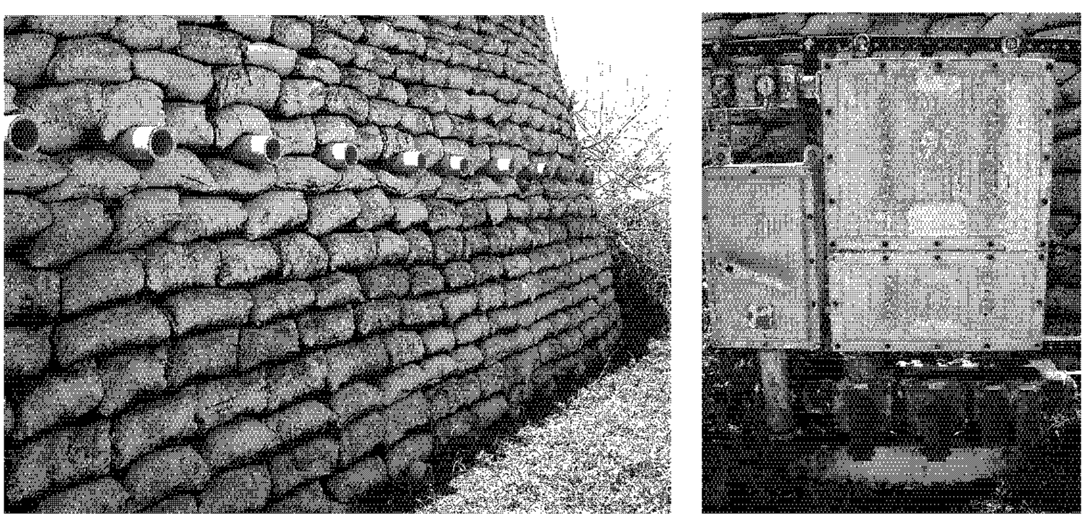

Figure 23. Revetment pipe weep holes (left) and power panel (right) (ERDC-CERL, 2007).

Figure 24. Safety enclosure modification at Pad 22 cable trench addition (ERDC-CERL, 2007).

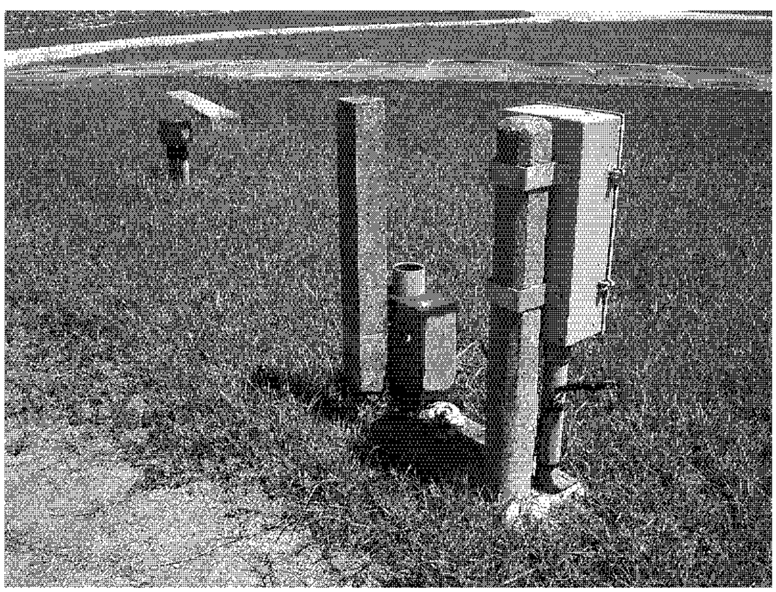

Figure 25. Camera pad No. 3 showing communications terminal box and power terminal junction box; junction box for nearby floodlight pole can be seen in background (ERDC-CERL, 2007).

Figure 26. Utility room with power receptacle post (left); typical fire alarm pedestal (right) (ERDC-CERL, 2007).

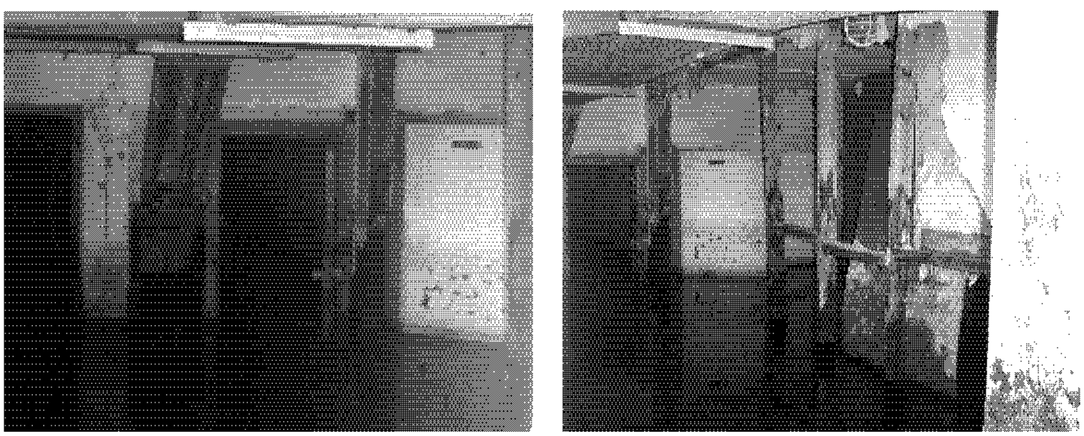

Figure 27. Interior views of flooded utility room (USAF, 2002).

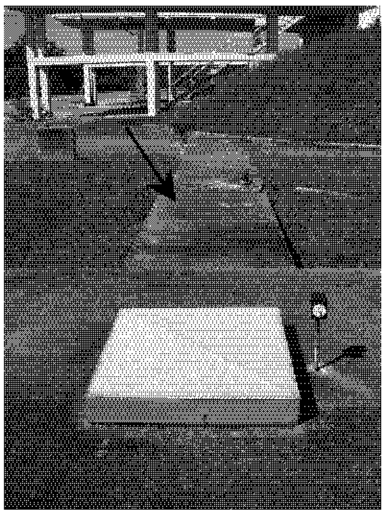
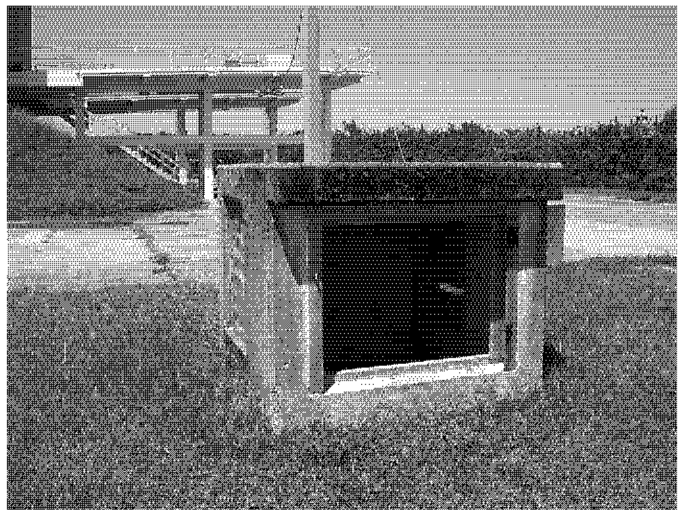

Figure 28. Tunnel from utility room (left); utility tunnel air intake (right) (ERDC-CERL, 2007).

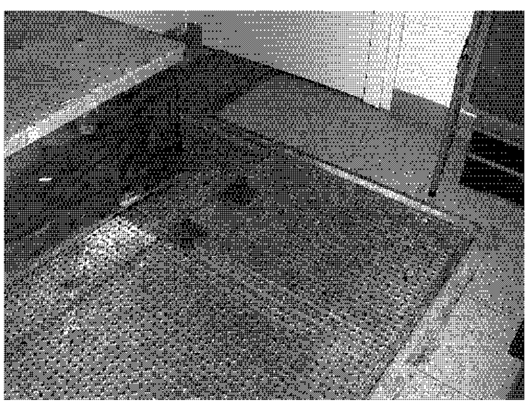


Figure 29. Communications pit (left) and work room pit (right) (ERDC-CERL, 2007).

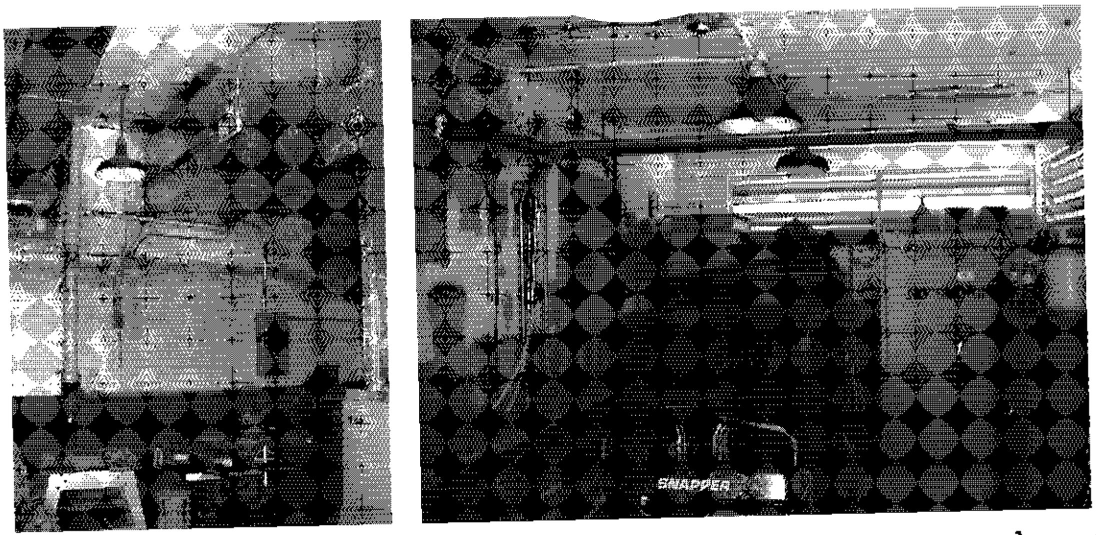

Figure 30. Air conditioning room (left) and compressor housing (right) (ERDC-CERL, 2007).

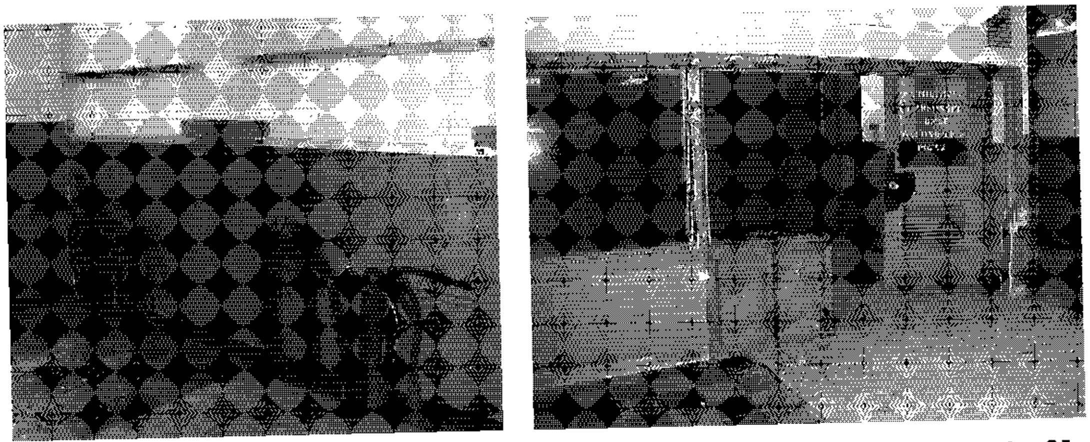

Figure 31. Control house conduit coming through 'false' floor (left); added partitions (right) (ERDC-CERL, 2007).

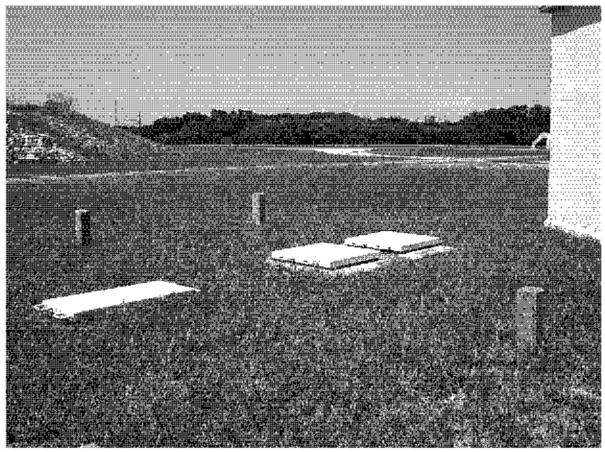

Figure 32. Control house sewage disposal system (ERDC-CERL, 2007).

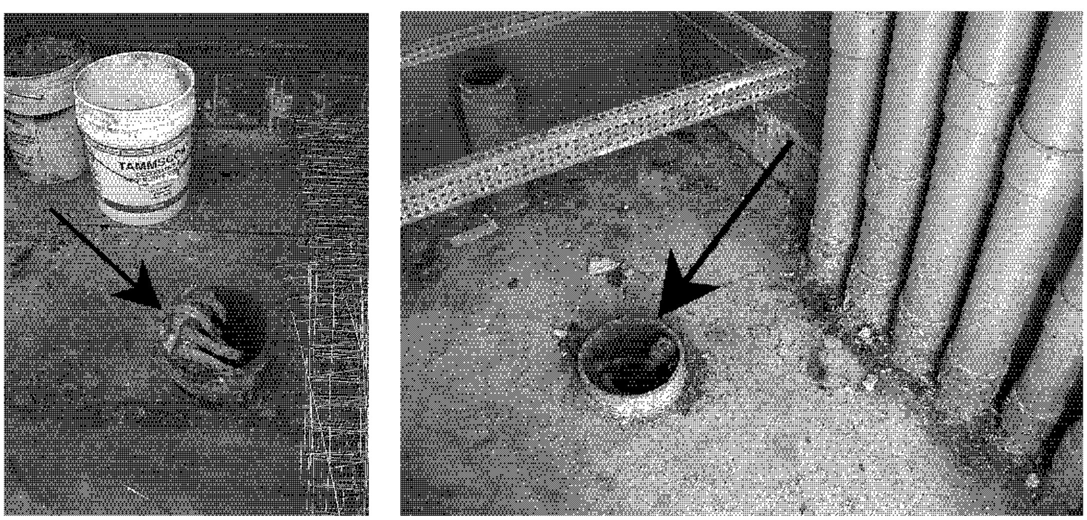

Figure 33. Control house fuel line pipes on first floor (left) and in hazard area (right) (ERDC-CERL, 2007).

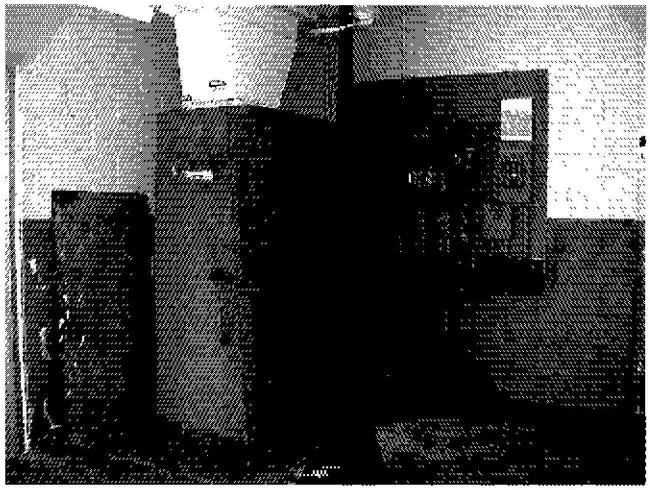

Figure 34. Control house second-floor self-contained cooling unit (ERDC-CERL, 2007).

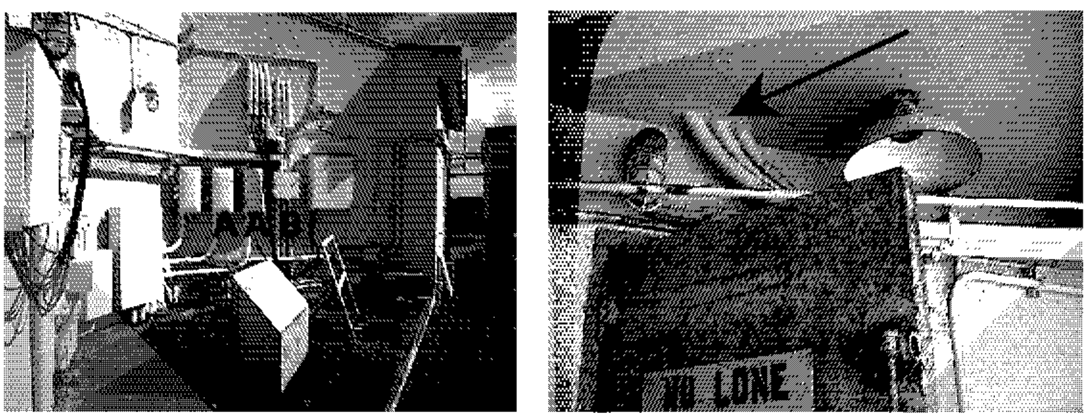

Figure 35. Launch building camera balcony (left) showing terminal boxes for sequential cameras (A) and TV cameras (B); TV camera conduit routed to control house (right) (ERDC-CERL, 2007).

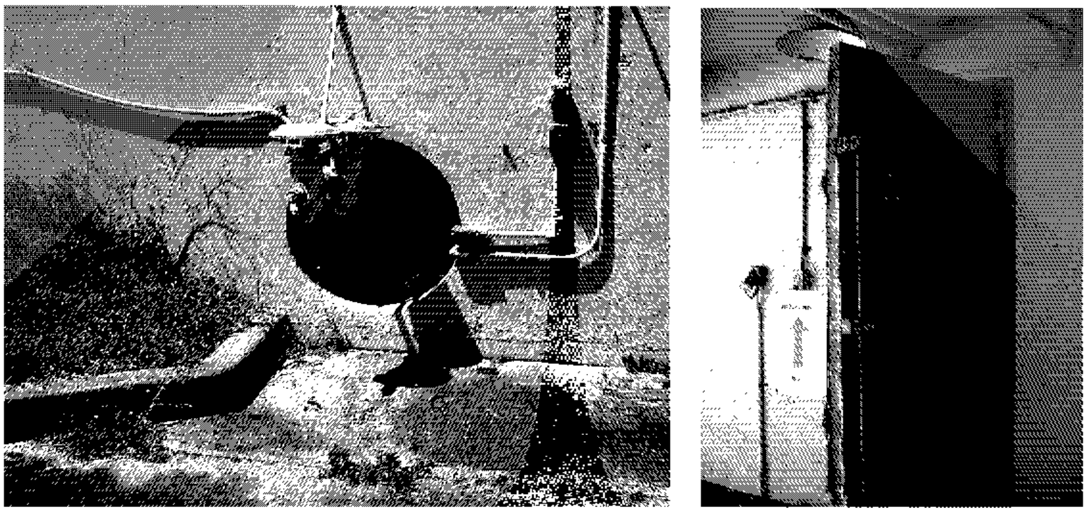

Figure 36. Launch building concrete pipe tunnel for CO_2 drop (left); steel entry door and adjacent CO_2 discharge button (right) (ERDC-CERL, 2007).

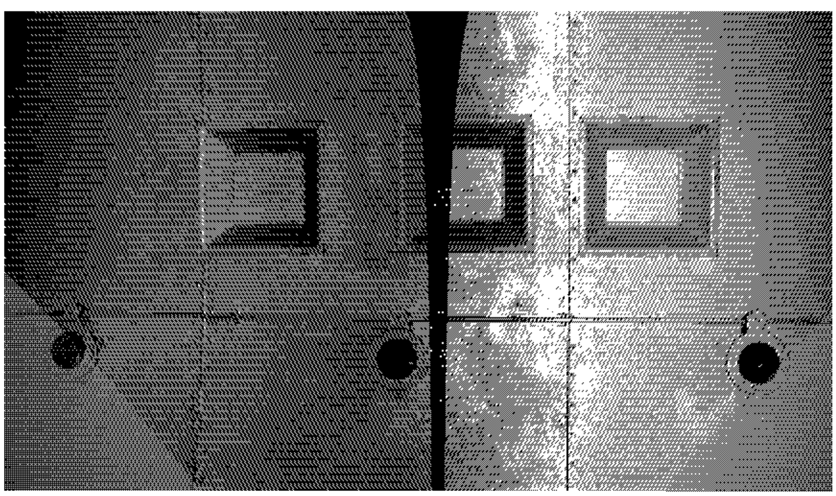

Figure 37. Launch building recessed lights (circular) and cameras (square) (ERDC-CERL, 2007).

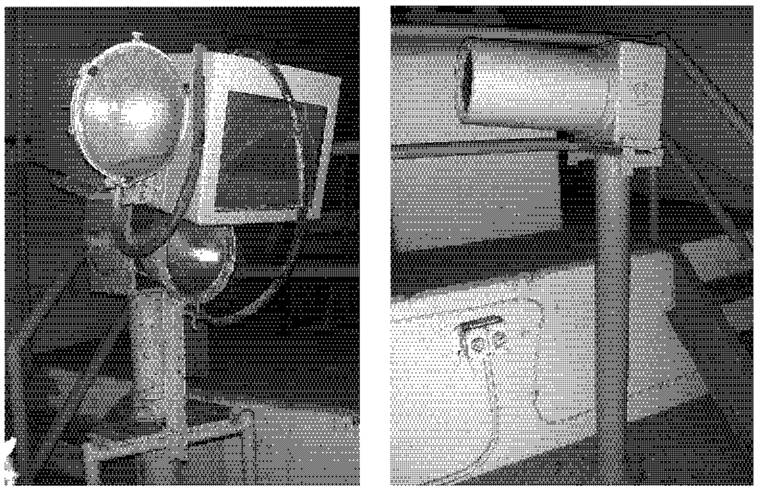

Figure 38. Launch building platform camera and lighting equipment (ERDC-CERL, 2007).

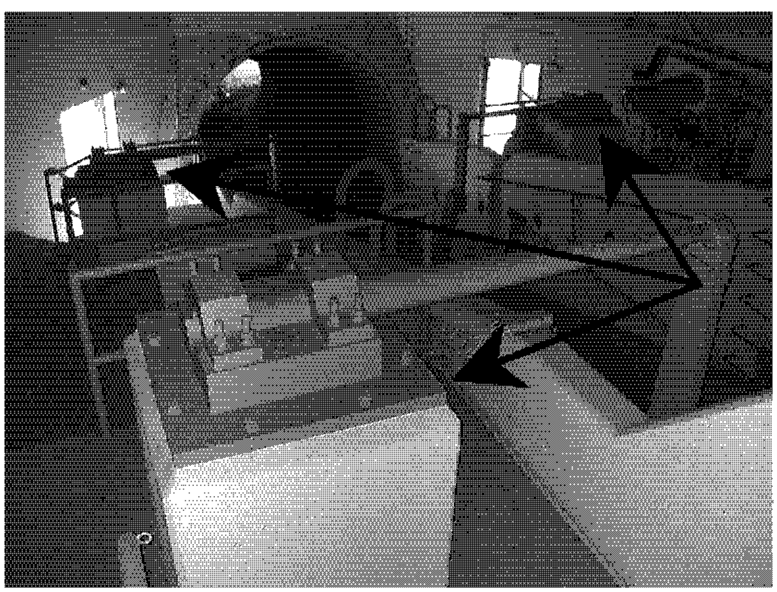

Figure 39. Launch bay 2 spring support assemblies (ERDC-CERL, 2007).

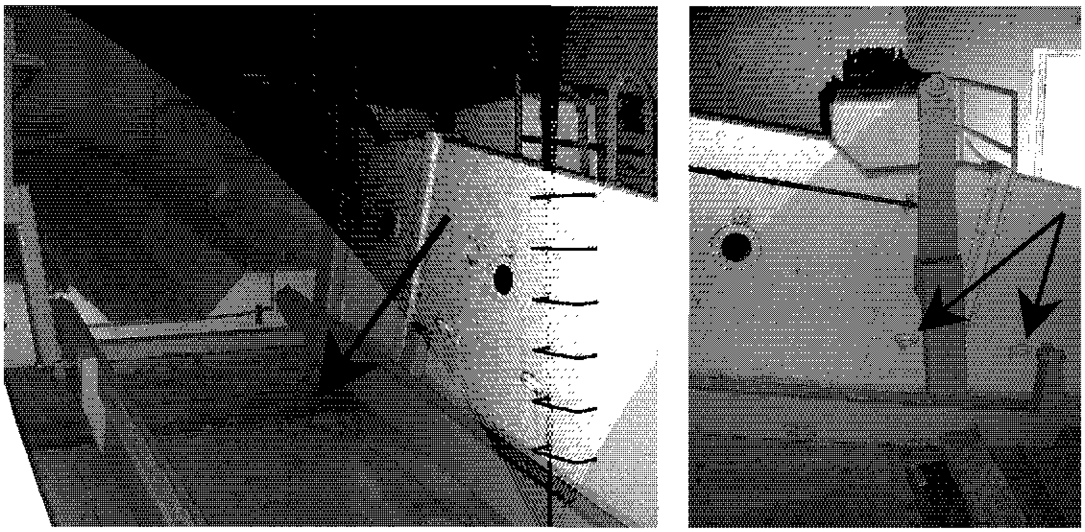

Figure 40. Launch bay 2 upper-end lift pit (left) and bottom-end tie-down fittings (right) (ERDC-CERL, 2007).

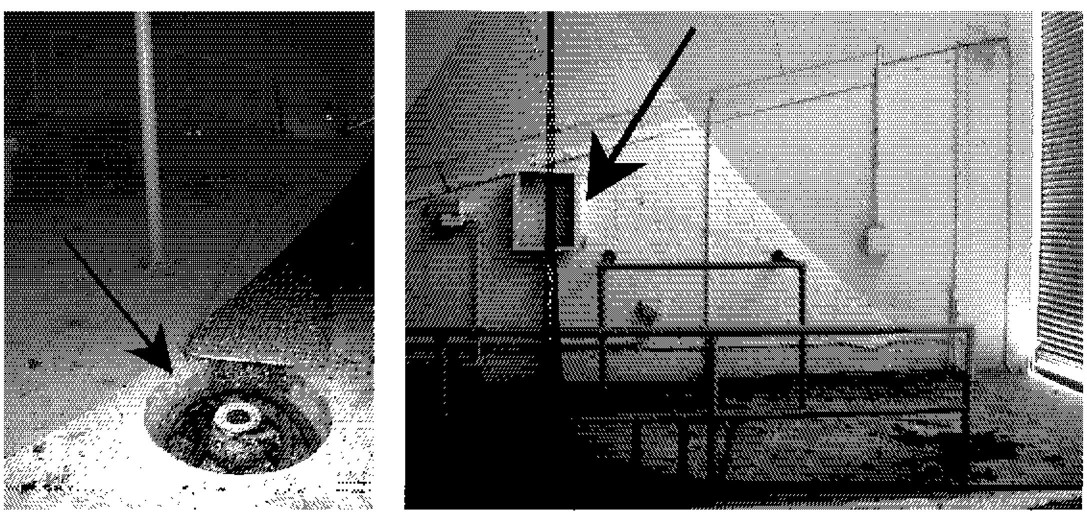

Figure 41. Launch building azimuth alignment unit mount (left) and MOPS cabinet (right) (ERDC-CERL, 2007).